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Managing Necessary Paradoxes of Broad-Based, Discontinuous, High-Technology Products Through Organizational Structure

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Managing Necessary Paradoxes of Broad-Based, Discontinuous, High-Technology Products Through Organizational Structure

by

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Dedication

To my family for all their love and support. My wife, Claudia and our wonderful daughter Adriana who was born during the pursuit of this master's degree. To my mother for setting the example of hard work and dedication. And to everyone else who has helped me grow both personally and professionally.

Abstract

Managing Necessary Paradoxes of Broad-Based, Discontinuous, High-Technology Products Through Organizational Structure

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In this paper, I explore what competencies are required for a company with broad-based, discontinuous, high-technology products. Many of the competencies the company must support are seemingly contradictory. Some examples include managing deliberate versus emergent strategy, market focus versus disruptive design, and exploration versus exploitation. I propose a specific organizational structure to support such paradoxical competencies for a company with these characteristic broad, discontinuous, high-technology products.

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INTRODUCTION

Many products are *endpoints;* complete solutions that solve a specific problem in a specific market and require little user integration. As the market evolves, this integrated architecture which was initially required to meet the performance needs of the market gives way to a modular approach that provides different value that the integrated solution could not (Christensen & Raynor, 2003, pp. 151-152). This shift is identifiable in the measurement instrumentation and control areas where modular offerings are gaining popularity in, and capability to satisfy applications traditionally suited to traditional integrated architectures.

This shift to modular products exposes distinct management challenges. This paper focuses on the challenges presented in designing products at a company with the following three distinguishing characteristics: (1) serves a broad set of customers in multiple markets with varied solutions; (2) presents an alternative product that is discontinuous from previous consumer solutions; and (3) develops products which exploit new technology capabilities.

Instrumentation Modularization

Traditional instrumentation approaches are primarily self-contained devices that perform specific functions as a single package thus termed “box instruments.” National Instrument’s uses Personal Computer (PC) technology to host a wide variety of I/O including Analog to Digital (A/D) converters and Digital Input and Output (DIO.) These combine to create “virtual instruments.” Key selling points of this modular approach include an often-lower price point, increased flexibility, and scalability of performance with PC technology.

(1) NI's modular products can be likened to components as they are often applicable across a wide variety of applications and markets. This diversity is apparent through the company statement that "no industry makes up more than 10% of revenue" (National Instruments, 2009).

(2) NI's modular approach is markedly different to the end customer than historical solutions. While flexible, the modular components must be integrated to create a complete instrument or control system. Instead of fixed user interface in buttons, knobs and a relatively static display, modular solutions often use a flexible virtual interface customized and presented on a computer monitor. The user must change behavior to adopt the modular solution.

(3) Two key technology categories enable competitive modular instrumentation. First, PC technologies are required for both increasing processing power and increased bus interconnect throughput. Second, measurement technology including D/A and A/D converters (Digital to Analog) converters and digital transceivers enable smaller, lower power modular devices to provide the same performance as traditional solutions. The frequency (sample rate) versus resolution is a key indicator of changing technology capability for instrumentation. Figure 1 illustrates the improvement in "off the shelf" technologies while Figure 2 illustrates bus interconnect technology improvement in bandwidth and latency.

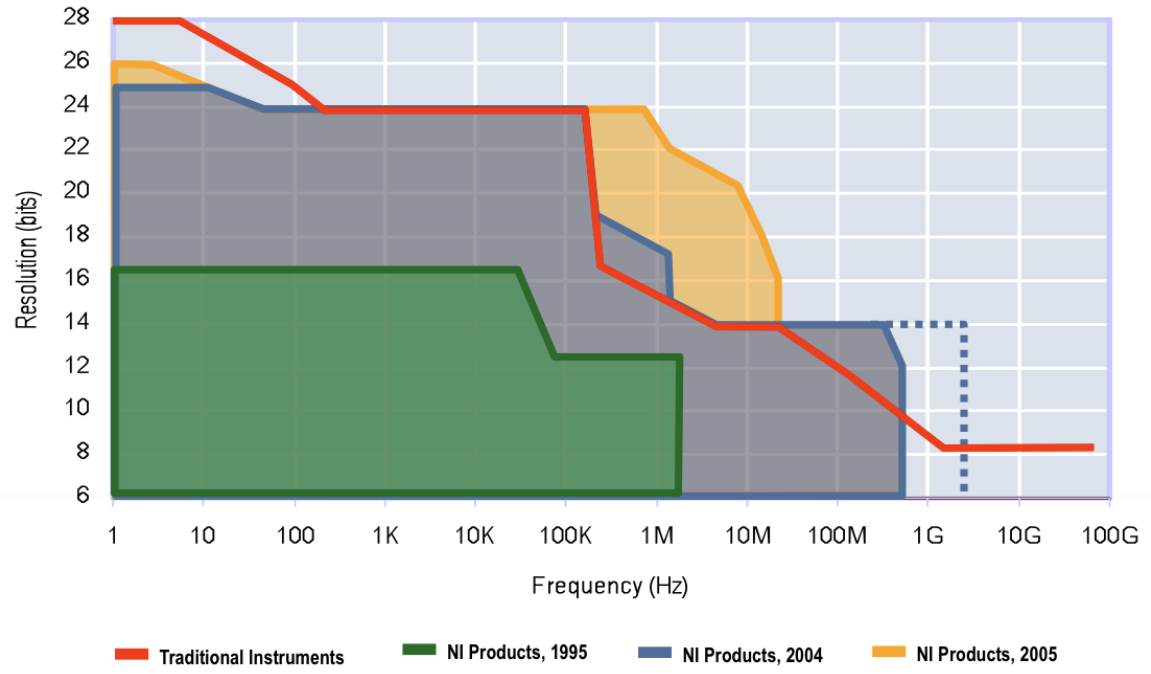

Figure 1: Frequency vs. Resolution for Modular and Traditional Products

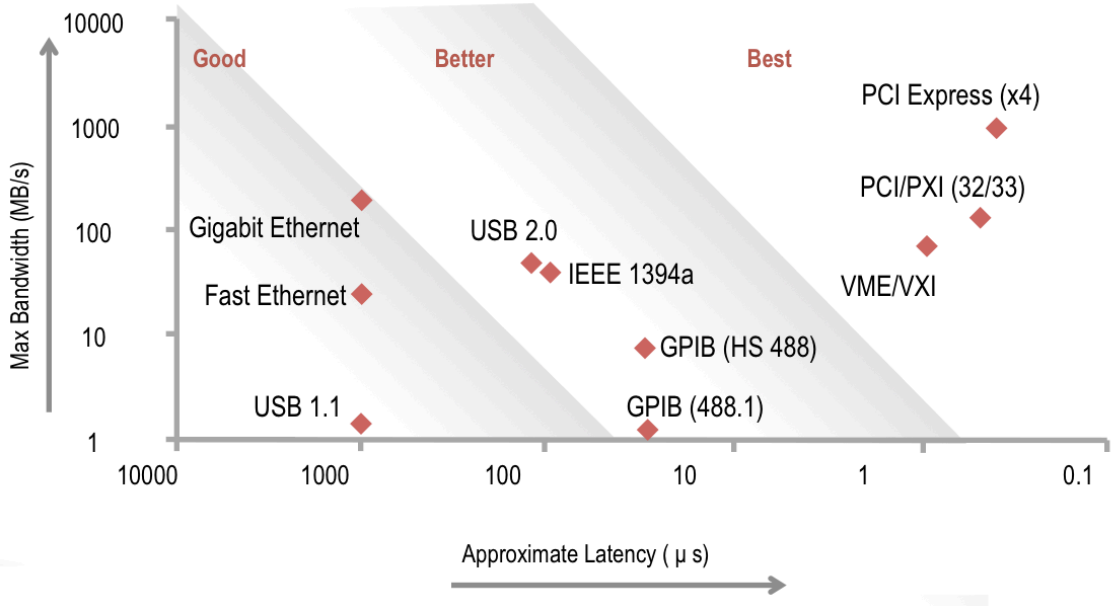

Figure 2: Modular Instrument Bus Technology Comparison (National Instruments, 2009)

PRODUCT GROUP ANALYSIS: TIMING AND SYNCHRONIZATION

This paper focuses on the Timing and Synchronization (T&S) product family due to its broad impact to other NI products and the perspective the author has as the Group Manager of the R&D area. As a category, Timing and Synchronization is concerned with the location of events in time. With possible application across NI's portfolio and industries, it inherits the same prioritization challenges that NI has in making investment decisions.

One example of value T&S provides is synchronizing I/O distribution across wider distances or with larger channel counts than possible with alternative solutions. This was used at Boeing for microphone I/O to build an Acoustic Holography system that spanned several hundred meters and allowed for full-scale tests to identify and minimize sources of aircraft noise. A second application is a high channel count, localized (a few meters) digitizer system for cancer research. And a third is the coordination of multiple measurement and control systems in a production plant where test instruments must coordinate with ejectors to precisely remove units if they are determined to be faulty. Each of these applications serves a different industry with a different set of products and performance requirements.

T&S has widely varied requirements for precision depending on the application area. The precision required for synchronizing I/O generally has precision requirements from picoseconds (10^{-12}) to microseconds (10^{-6}). The control area is often less demanding with requirements in the millisecond (10^{-3}) range. In total, T&S technology has applicability over a performance range that differs by 9 orders of magnitude. This creates vastly different product demands with must be managed against varied technology options.

INITIALLY-VISIBLE CHALLENGES

Breadth and Communication

Many corporations fit into one of two models. The first is satisfying a single gap across multiple markets or sets of customers such as selling soda across multiple regions. This might even include minor variations of the base product to better meet the demands of the different markets. But fundamentally, the corporation creates one product to satisfy multiple markets. Similarly, a company might focus on satisfying a particular market so thoroughly that they solve a variety of problems for this market in the process.

One of the most important investment decisions a corporation can make is what product to produce. Communication between those who design the product and potential consumers is crucial to learn and improve decision-making. In either of the previous two models, the organization is satisfying a one-to-many relationship where the likely communication path is simple aggregation to the primary area of focus (the single set of customers or single product/solution.)

Some organizations extend these primitive forms to have multiple products or product groups servicing multiple markets. But on closer inspection, it may be a simple extension of the base forms where the underlying communication from those producing the product to those who might purchase it is still fairly straightforward.

National Instruments' modular products are combined to solve different problems across different markets. And importantly, this combination is different. Unlike an organization with multiple product areas serving a specific problem or specific market, NI products (and thus the communication channel) do not have a direct relationship to the end problem they solve or the market for which they solve it.

One example is a customer seeking to perform machine condition monitoring. Machine condition monitoring is a method by which a machine's sound and vibration

output is monitored to preemptively identify failures. These applications span multiple industries and primarily use a combination of DSA (Dynamic Signal Acquisition), multipurpose data acquisition (DAQ), and Timing and Synchronization hardware. Alternatively, aerospace customers like Boeing use the same DSA product over a different distance and without the complement of multipurpose DAQ. Lastly, these same boards can be used in structural applications to measure strain and vibration in civil applications.

A similar multitude of uses is common across the 20+ discrete product lines at NI. This many-to-many relationship has no clear communication path making it indeterminate where learning will—or should—occur to improve decision-making.

Timing and Synchronization: An Indirect Goal

Timing and Synchronization is usually not the end goal of a National Instruments customer. Instead, T&S is combined with other product offerings to increase the value of the system. In the Boeing example, T&S made a coherent system with over 400 channels across hundreds of meters possible but it never showed up in the customer's enumerated goals. This additional abstraction from the problem the customer is trying to solve increases the difficulty in identifying possible applications of T&S to predict future value of alternative investment options as a decision making criteria.

Customer Goal	Product Requirements	Implicit Timing and Sync
Measure sound of full scale model	*n* DSA I/O channels over *m* distance	PXI-Based 100ns timing and synchronization

Table 1: T&S as an Indirect Need from Customer Requirements

Benefits of Breadth

Despite the challenges breadth and product diversity present, many significant advantages are characteristic of broad firms. Notable are the increased survival rates, higher proclivity to disruptive innovation, easier adjustment to environmental changes and behavioral emphasis on growth and innovation (Mcevily, Ren, Roy, & Sorenson, 2006). Additionally, product offering breadth offers capability to solve "odd-ball" applications which are either too low volume or too new to be profitably pursued by a fixed-function product. These benefits of breadth should be maintained. This paper's hypothesis is that an organization with the three aforementioned characteristics must be able to balance the breadth with focus to be effective in making the right product decisions for both the short and long term.

PRIOR WORK

Market Orientation

The many-to-many product-to-markets structure for companies like NI makes identifying, understanding and communicating with the potential customer significantly more difficult.

SEGMENTATION

Segmentation is a key method to build focus towards the end customer. Through segmentation, the organization hopes to delineate a population in some useful way that is superior to looking at the population as a whole. This segmentation is then used to optimize product and business decisions.

An everyday example might be surveying consumers of tea for the temperature they prefer. The average response might indicate that lukewarm is the temperature the average customer would prefer when in fact a strategy of segmentation would indicate that half prefer iced and half prefer hot and almost none would prefer the "average" (Harrington & Tjan, 2008).

Some segmentation methods focus on customer characteristics (demographics, race, age, social status) of potential consumers while others seek to determine who would buy the same product, pay the same price or has the same "job to be done" (Christensen & Raynor, 2003, p. 87).

In the purest sense, a product directly seeks to perform the "job to be done." Thus, an understanding of the possible jobs to be done provides an indicator of the possible set of products. Note that while the job may be common across markets, one must be careful to also consider the price tolerance of the different customers, which may indicate additional product permutations are necessary to maximize return.

MOORE'S DISCONTINUOUS INNOVATION

Unfortunately, most segmentation methods do not consider one of the most important delineations for a company like NI. Moore terms Continuous Innovations for those that do not require customers to change behavior. Discontinuous Innovations however, are those that require the customer to change behavior. An everyday example for a customer familiar with using an existing stove is a better stove (Continuous) versus a microwave (Discontinuous) product.

Continuous Innovations might have minor impediments to adoption while Discontinuous Innovations are likely to have significant obstacles to market adoption. Moore enhances the product adoption lifecycle by adding 'cracks' between key adoption events indicating key market obstacles to adoption. The most significant of these is a 'chasm' between the early market and the pragmatic early majority market.

NI products have a different value chain than alternative solutions. The customer plays a larger part in the integration and customization of the end solution. NI's products fit Moore's description of a Discontinuous Innovation since they require the customer to "change their current mode of behavior." (Moore, Crossing the Chasm, 2006, p. 10). Such innovations must overcome distinct obstacles to adoption that Moore outlines.

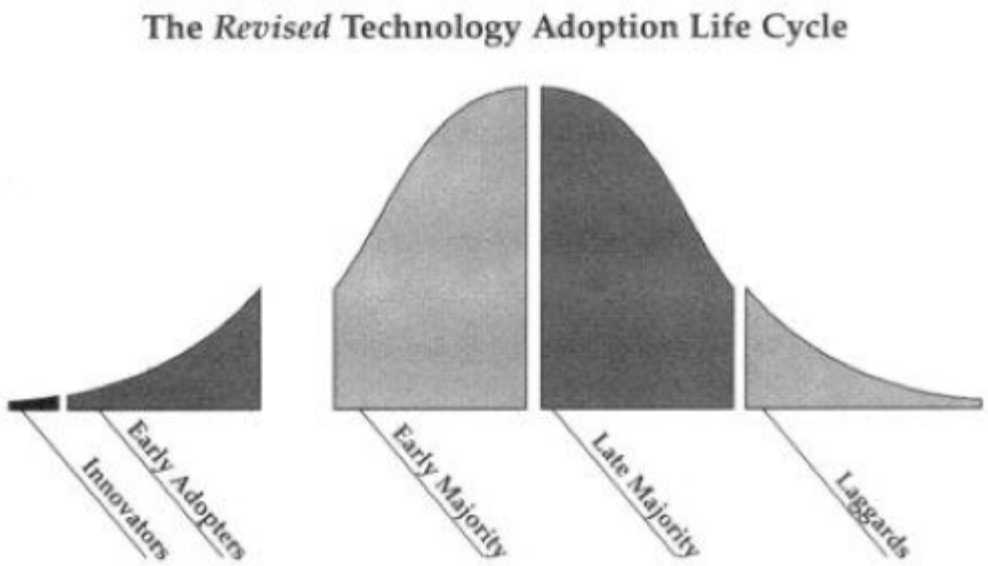

Figure 3: Moore's revised technology adoption lifecycle (Moore, Crossing the Chasm, 2006)

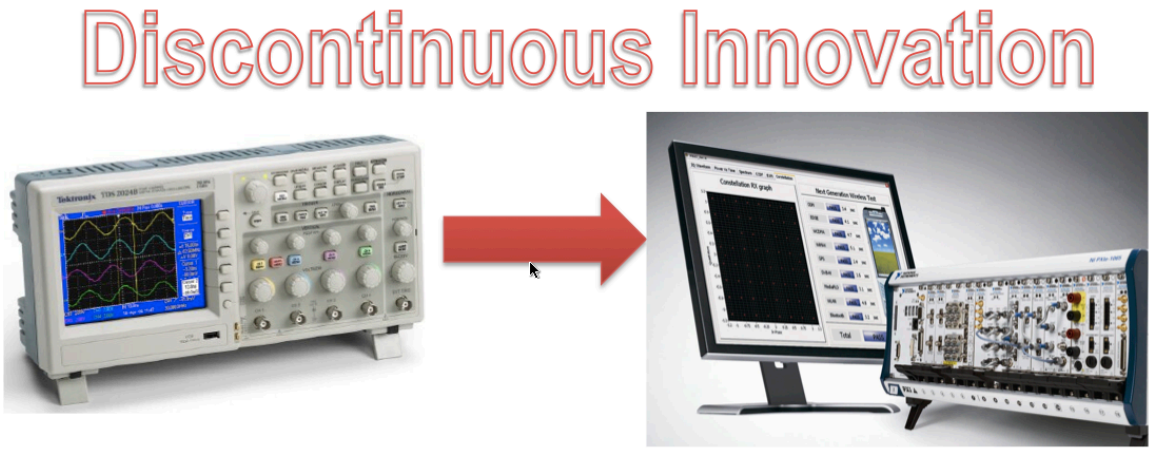

Figure 4: Illustration of Traditional vs. Virtual Instrument

GARNERING ADOPTION FOR A DISCONTINUOUS INNOVATION

Of Moore's four defining characteristics of a market, perhaps the most useful relative to product adoption is the requirement that the customers "reference each other

when making a buying decision." (Moore, Crossing the Chasm, 2006, p. 28). With customers across multiple industry segments, self-referencing critical mass is not a natural outcome for a company like NI. To achieve market penetration and maximize profit potential, one must plan an explicit strategy to take action for each phase of resistance within a set of self-referencing customers.

The product adoption lifecycle breaks new product adoption into five distinct sets of customers. It outlines that adoption begins with Innovators and continues through Early Adopters, Early Majority, Late Majority and Laggards: each of which have common psychographics. To help ensure adoption, a product must consider each group's needs and fulfill them. While the earliest part of the market may be the easiest to achieve, it comprises only a small fraction of the potential market. Capturing the market requires satisfying each distinct group's needs.

Notable Cracks in the Market Adoption Lifecycle

The first crack is between the innovators and early adopters. This is where a "technology product cannot be readily translated into a major new benefit." A crack of similar scale occurs between the early and late majority where "the early majority is willing and able to become technologically competent, where necessary;" with the late majority less willing to do so. But the most formidable transition that must be overcome is the chasm from which Moore gives the book its name. This is where customers now seek "evolution not revolution" and "early adopters do not make good references for the early majority." This is the most difficult transition for companies with discontinuous products. Successfully crossing this natural chasm requires significant focus of the seller towards the self-referencing market. (Moore, Crossing the Chasm, 2006, pp. 17-22).

Crossing the Chasm D-Day Strategy

To cross the chasm, Moore suggests focusing on a carefully selected "beachhead" market and building a base of self-referencing pragmatist customers to ensure a successful transition across the chasm. Achieving this critical mass is crucial as it allows other pragmatists to fall in line to the proven solution and market leader. The beachhead strategy requires the entire organization prioritize to support the effort, from product decisions to marketing and sales alignment. The focus is at odds with the natural endeavor to win any sales possible; a seemingly valid one for a broad company. Instead, Moore argues to avoid a sales-driven strategy and with it, purposefully exclude customers so focus can be given to the beachhead that must be achieved.

Focusing to a Fault: Led Astray by the Best Customers

The goal of Moore's strategy is not necessarily to build products that are so pointed that they satisfy only a single market. Instead, our goal to continue building broad products must be augmented by prioritizing market-specific features where necessary to garner adoption of these discontinuous innovations. Some potential outcomes of this strict market focus must be considered.

Clayton Christensen's "The Innovator's Dilemma" and "The Innovator's Solution" provide a useful theory for investment in innovations. Christensen segments innovation into two main categories: Sustaining and Disruptive.

"A Sustaining innovation targets demanding, high-end customers with better performance than was previously available." (Christensen & Raynor, 2003) In short, a sustaining innovation fits the model most often pursued by standard business practices that usually seek higher margins and higher profits. It is the natural evolution of a business over time. In fact, it may be a direct outcome if we improve our market orientation to be in line with "Crossing the Chasm's" D-Day Strategy.

Disruptive innovations however do not bring better products to existing markets but instead "redefine the trajectory" of performance often appealing to either "new or less-demanding customers" (Christensen & Raynor, 2003, p. 34). Christensen argues that disruptive innovation provides more opportunity for growth through either New Market or Low-End disruptive opportunities. New Market opportunities create new consumption where previously nonconsumption was the primary option. Low-End disruption enables profitability at a lower price point for customers who might be overshot by the primary market offering.

In both cases, the effect of leveraging a disruptive innovation is to improve the likelihood of success by decreasing the threat of incumbents. In New Market opportunities, incumbents are likely to play a minor role as they continue to serve the most profitable area of their existing customers. And Low-End disruption is often unappealing to incumbents because it offers decreased margins and profitability than the demanding customers. This provokes them to flee towards those sustaining up-market innovation rather than fight. (Christensen & Raynor, 2003)

As a company building market focus, the apparent consideration is to build a capability for continually analyzing the threat of disruptive entrants lest our best clients lead us "…down the primrose path" (Anders, 2007).

POTENTIAL DISRUPTION BENEFITS

One should not only consider disruption as a threat to business. As Christensen outlines, disruption can also be a strategy for increasing the odds of success against an incumbent. In considering the National Instruments product line, clear characteristics of disruption are apparent in the success of multiple product lines. When products launched,

the PC-based instrumentation strategy allowed for additional customization by the end user at a lower price point and with inferior performance than traditional instruments.

Despite this inferior performance on a traditional measure, the business grew from customers who valued other aspects of the product where modular instruments were superior. With increases in PC interconnect throughput, processor speeds, and converter components (such as D/A and A/D) available for modular instrumentation, NI has narrowed this traditional performance gap. Now leading traditional instrument vendors such as Agilent Technologies are investing in modular product divisions (Agilent Technologies, 2010).

If the business can recognize disruptive opportunities and threats, it can both defend positions as an incumbent and grow into new areas as an entrant.

COMPARISON OF CROSSING THE CHASM AND THE INNOVATOR'S DILEMMA

Both the Crossing the Chasm and Innovator's models apply directly to National Instruments in seeking to achieve growth versus entrenched competitors through different performance characteristics than historically prevalent. With a different technology architecture and value chain than alternatives, it is appropriate to evaluate opportunities where an investment might provide a disruptive position. This disruptive advantage may be a key attribute to improve the odds of achieving successful growth.

Both Christensen and Moore dissect how innovations become profitable business. While sustaining, continuous innovations might seem the most straightforward path in satisfying customer's demands, Christensen argues that seeking disruptive innovations provides the greater opportunity for growth. These New-Market or Low-End disruption opportunities provide advantage against incumbents.

Disruptive innovations—specifically New Market—come about because a new market of previous non-consumers redefines the value of an innovation. It must be considered that these disruptive innovations are likely to have discontinuous characteristics since previous non-consumers are likely changing behavior to adopt the innovation.

Table 2 illustrates each of these concepts using an example of computers based on the x86 microprocessor architecture. A Continuous, Sustaining innovation would be a processor that increases in computing speed. This satisfies an existing market's most demanding customers with an architecture that is compatible with previous designs and simply faster. Trying to satisfy those same demanding customers might alternatively be accomplished with a multi-core (multiple computing core) CPU architecture or using a GPU (Graphics Processing Unit); both of which require modification to the software to take advantage of the new architecture thus making it Discontinuous.

Continuous, Low-End Disruptive Innovations would include lower performance CPU offerings that enable a lower price as well. This might be accomplished through die shrinks or other new technologies to decrease cost per unit. A Discontinuous alternative could be a new operating system like Linux (free per unit sold) enabling a lower price but requiring changes to the software and user's behavior to use the different OS. Continuous, New Market Disruptive Innovations could include leveraging a processor architecture like Intel's Atom. The Atom architecture uses the same x86 instruction set but is significantly lower power than previous x86 processors. This enables the same software and same behavior the customer is used to but in a completely new application. A Discontinuous alternative might be Apple's iPhone with its ARM architecture (an alternative to the x86 instruction set) and completely new operating system. It requires both a change in behavior but also enables a new market application.

	The Innovator's Dilemma / Solution			
Crossing The Chasm		Sustaining	Disruptive	
			Low-End	New Market (New-Valuation)
	Continuous	Faster Clock Speed	Lower Performance x86 (Die shrink / cost per processor)	Handheld – Atom x86
	Discontinuous	Multi-Core, GPU	Linux	Apple iPhone Apps - ARM

Table 2: Comparison of Moore's Discontinuous concept and Christensen's Sustaining and Disruptive Innovations

NI has made the modular approach for instrumentation simpler than alternatives through technologies like graphical programming and configuration utilities. This ease of use has made it possible to bring the unique integration of these components closer to the domain experts. Despite these advances, the modular approach may require the customer to have a skill set or commit effort to integration different from that of previous solutions. These conditions must be analyzed on a per market basis to ensure we can achieve market penetration for the Discontinuous offering.

SUMMARY OF APPLICABLE WORKS

With broad applicability and differentiated capabilities, many of NI's products garner success without focused segmentation on a per-market basis. While beneficial for resilience across individual industry fluctuations, this diversity dilutes customer feedback across these various applications and markets presenting a challenge for product prioritization.

A completely broad perspective is non-optimal since adoption is primarily across many diverse early markets and is less likely to attain deeper, higher volume market adoption. While the initial solution might garner success broadly, it may not necessarily be palatable to all customers throughout a particular market due to the discontinuous nature of the products.

These characteristics of NI's products must be considered if we are to prioritize and maximize the ROI. If unchecked, the broad applicability across various applications and markets would dilute resources across different market requirements and decrease the odds of overcoming crossing Moore's Chasm. Not considering the changes in customer behavior necessary to use the product would leave us blind to the barriers to market adoption that must be overcome to achieve pervasive adoption. We will leverage applicable models to evaluate how we might maximize ROI by focusing efforts beyond the broad initial market potential.

Designing the product to allow for deeper market adoption will likely require an understanding of the needs of specific customer types and their specific requirements. But following a specific market's needs too closely must be balanced with exploration to identify both areas where the business might be disrupted and where it might be expanded to opportunistically disrupt others and increase the odds of success. Balancing the broad nature of NI modular products against the benefits of focus is the goal of this study.

SUGGESTED STRATEGIES

The competencies required for success with a broad, high-technology company serving multiple market segments might seem at odds with the focus needed to gain adoption for discontinuous innovation. Specifically, Crossing the Chasm identifies the need for focus to garner adoption for discontinuous innovations while The Innovator's Dilemma warns of following one's "best" customers too closely and instead recommends an openness to emergent, entrepreneurial opportunities at the outset with a shift to a deliberate strategy once a clear path forward has emerged. There are clear requirements to serve specific markets and garner adoption yet build broad, modular products with applicability across multiple domains to leverage both economies of scale and build diversity to weather industry-localized economic downturns.

Suggested Capabilities Required

MARKET LIFECYCLE FOCUS FROM INCEPTION THROUGH ADOPTION

As described extensively above, "Crossing the Chasm" enumerates the rationale for a focused, D-Day strategy to garner adoption for a discontinuous innovation like NI products.

DISRUPTIVE DESIGN AND CREATIVITY

A market orientation capable of identifying disruptive opportunities and threats might prove the first step in managing an organization through disruptive shifts. But traditional methods of garnering product design feedback from the anticipated customers themselves is likely to pose particular challenges for organizations investing in disruptive or revolutionary products. Despite the difficulty, the organization must be capable of identifying product needs, wants and opportunities that are disruptive in nature.

Customers can be limited by their expertise. Being experts in the problem doesn't necessarily prepare them with the tools to design the ideal solution. Their historical perspective can pose what "psychologists call 'functional fixedness—the human tendency to fixate on the way products or services are normally used, making people unable to imagine alternative functions." Or customers may enumerate the problem in a way that assumes a particular solution, providing less opportunity to create a novel solution (Leonard, The Limitations of Listening, 2002). Christensen's warns against trying to use market-sizing methods to predict something truly disruptive. And Drucker warns "One cannot do market research for something genuinely new. One cannot do market research for something that is not yet on the market" (Drucker, 2001, p. 145).

For an organization to be capable of disruptive design, it must be able to challenge the status quo and generate creative solutions since disruptive capability is often based on an "asymmetry of perceptions" (Christensen & Raynor, 2003). This necessitates creativity, which "is a process of developing and expressing novel ideas that are likely to be useful" (Leonard & Swap, When Sparks Fly, 2005, p. 6).

IDENTIFY AND EXECUTE BOTH DELIBERATE AND EMERGENT STRATEGY

Strategy is often envisioned as explicit deliberation and a firm's decisive shift of the organization into action. More accurately, this is Deliberate Strategy. "The deliberate strategy-making process is conscious and analytical." (Christensen & Raynor, 2003, p. 215) Where Deliberate Strategy is intentional, Emergent Strategies are "patterns or consistencies realized despite, or in the absence of, intentions." (Waters & Mintzberg, 1985)

Deliberate strategy's importance shouldn't be understated. The Innovator's Solution describes the first point of possible failure as missing the disruptive opportunity

in the first place. The second is a lack of a Deliberate Strategy, which causes firms to be left behind. Deliberate strategy is key to making the race up-market.

"Research suggests that in over 90 percent of all successful new businesses, historically, the strategy that the founders had deliberately decided to pursue was not the strategy that ultimately led to the business's success" (Christensen & Raynor, 2003, p. 221). And Drucker reiterates, "When a new venture does succeed, more often than not it is in a market other than the one it was originally intended to serve, with products or services not quite those with which it had set out, bought in large part by customers it did not even think of when it started, and used for a host of purposes besides the ones for which the products were first designed." To attempt success in disruption requires a capability for embracing and leveraging the unexpected. And instead of casting aside these "exceptions," the organization must "go out and look at it carefully and as a distinct opportunity" (Drucker, 2001, pp. 145-147).

Exploiting and Exploring

Extending the concepts of 'Deliberate' and 'Emergent' Strategies, much research uses the unequal but similar categories of 'exploiting' and 'exploring' respectively. "Whereas exploitation is associated with activities such as 'refinement, efficiency, selection, and implementation,' exploration refers to notions such as 'search, variation, experimentation, and discovery' (Raisch & Birkinshaw, 2008, p. 376). Thus, while exploitation seeks to optimize the existing business, exploration explicitly seeks out new opportunities to help avoid the competency trap Christensen describes. (Raisch & Birkinshaw, 2008)

"Too much exploiting drives inertia and dynamic conservatism; exploitation crowds out exploration…. Similarly, too much exploration drives out efficiencies and

prevents gaining economies of scale or learning by doing" (Smith & Tushman, 2005). Thus, while the business must be capable of optimizing current business, it needs to also build a dynamic capability to refresh itself towards new opportunities.

SUGGESTED ORGANIZATIONAL STRUCTURE COMPONENTS

Design Guidelines

The organizational recommendation begins with the guidelines used to build the structure. These include:

1. The breadth business as the primary structure—the existing "stronger hand"
2. Leverage existing product breadth to identify possible focus areas where possible
3. Support for paradoxical thinking by designing areas of focus both in spite of, and to promote alternate perspectives within the structure
4. Divergence to allow groups to focus and build needed expertise
5. Convergence to maintain alignment, synergy and re-use
6. Capability for bottom-up discovery
7. Structured but adaptive
8. Support expertise in key phases of innovation

BREADTH: NI'S STRONGER HAND

NI products are naturally broad. The literature leads us to identify areas of focus an organization needs to support. We suggest NI seek to maintain the successful breadth through modular business while designing a structure to support the areas of necessary focus. "The best strategic moves for a company are ones that supplement rather than complement that company's current dominant business model" (Moore, Strategy and Your Stronger Hand, 2005). Thus, the areas of focus should not supplant but instead, complement the dominant, broad business model.

LEVERAGING BREADTH TO IDENTIFY OPPORTUNITIES FOR DEPTH

As Moore describes in "Crossing the Chasm", the Early Majority is the group whose behavior creates the wide chasm; waiting until enough peers can be referenced to satisfy the pragmatic group. But the early market doesn't hold such a rigid requirement. Moore's defining characteristic that a market must self-reference still holds. It is simply that those in the Early Market tend to operate with lower barriers to other markets. In

fact, as technology adoption leaders, they likely build their own self-referencing network across the traditional industry boundaries. An example might be building a self-referencing network between those who use a tablet computer across any domain.

I noted this behavior in the use of cutting-edge NI Timing and Sync products by customers. Through online forums, it became apparent that Radio Frequency (RF) customers were referencing the solution presented in a whitepaper from a Sound and Vibration application. These customers did not exhibit the normal separation that would be expected to exist between these two markets. This presents a possibility that market separation that prevents referencing is not static, but variable. Figure 5 graphically illustrates the gradual increase in market isolation, which creates barriers to referencing between markets.

Additional characteristics of these users are in line with the characteristics of the early market. They were more technically savvy than their mainstream counterparts and could identify the potential benefit of the product despite its newness and lack of explicit value proposition directed at their space.

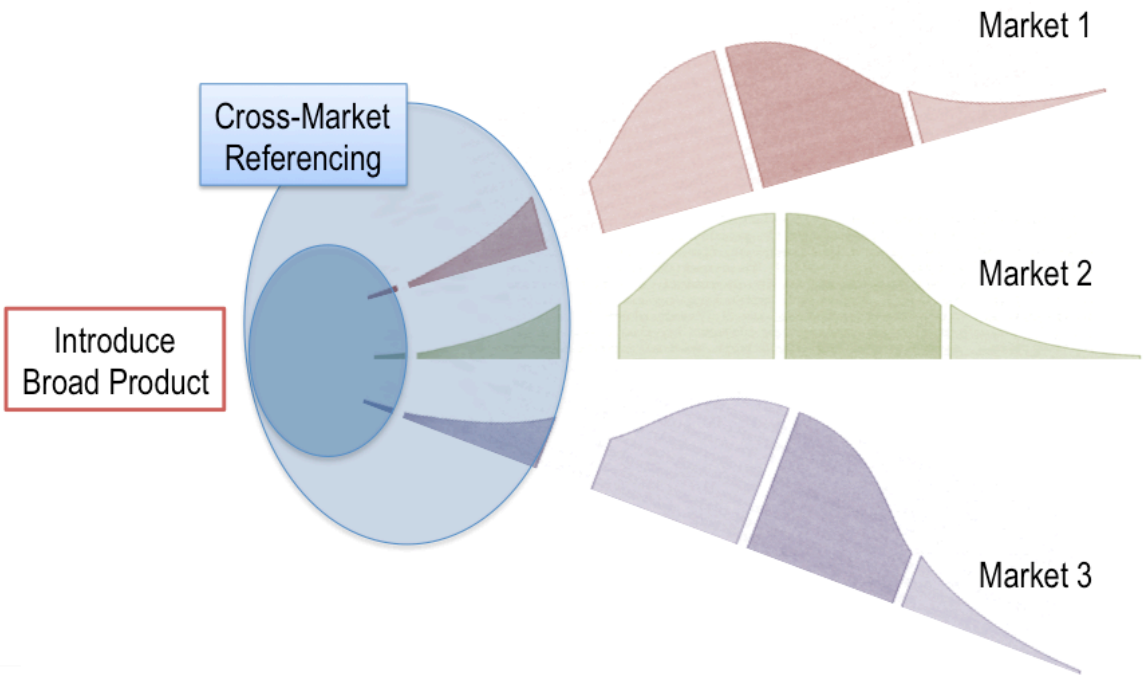

Figure 5: Variable Market Isolation

There are notable challenges breadth of business brings to product design decisions through an unfocused lens. But as we seek to build a model that selectively brings certain areas into focus, this initial broad applicability is a reasonable sample set to consider. By releasing broadly applicable products to the market, the areas of adoption could be a signal towards markets where a segmented, focused approach could provide additional product characteristics to prioritize.

The initial cross-market referencing, technology expertise, and individual enumeration of the domain-specific value propositions provide a lower barrier to garnering adoption for a broad product. After assessing the initial successes and failures, the organization should be able to learn and prioritize whether a focused, beachhead approach is needed to garner adoption for the discontinuous innovation in a more specific market.

GENIUS OF THE AND: PARADOXES AND AMBIDEXTERITY

It may seem at odds to develop simultaneous capability for both emergent and deliberate strategy, market focus and broadly applicable products, and the exploration of new possibilities and the exploitation of old certainties. But the organizational capability of managing such paradoxes is gaining traction as a necessary competency. It allows a successful organization to benefit from seemingly contradictory but complementary expertise; concluding in one such instance that the "long-term survival and success depend on an organization's ability to 'engage in enough exploitation to ensure the organization's current viability and to engage in enough exploration to ensure future viability'" (Raisch & Birkinshaw, 2008). In fact, "…organizational ambidexterity is best achieved by 'building a set of processes or systems that enable and encourage individuals to make their own judgments about how to divide their time between conflicting demands for alignment and adaptability'" (Bodwell & Chermack, 2010). By building this consideration into the organization I seek to provide the structured alignment of each handedness to complement each other.

Moore's "stronger hand" depiction is used to describe the difficulty building simultaneous coexistence for transactional products on one hand and complex customer-centric products on the other. We instead seek to leverage this building of handedness for different temporal goals within the same organization. These simultaneous goals are perhaps less at odds than Moore's example given that "organizational ambidexterity is best viewed from the multiple frameworks of organizational learning, technological innovation, organizational adaptation, strategic management and organizational design" (Bodwell & Chermack, 2010).

DIVERGENCE TO SUPPORT FOCUS AND BUILDING EXPERTISE

A broad company requires specific areas of expertise. These include areas of technical knowledge (digital design, analog design, power supplies, software, etc.), marketing expertise, etc. Divergence allows areas of the organization to build focus and through this focus, expertise. In some cases, particular product capabilities (and thus product lines) necessitate building areas of expertise. Examples include power line noise rejection in Digital Multimeters (DMMs) and phase noise rejection in high frequency Radio Frequency (RF) applications. Non-development areas of expertise include building an expertise in a particular customer type (Defense, Academic, etc.) or application area (Military, Energy, etc.).

Divergence is also required for product designs themselves. "Too much interlocking creates…indistinct products poorly adapted to their markets" (Brown & Eisenhardt, 1998, p. 60). These are not necessarily restricted to product technical capabilities. Other product characteristics such as price and terminology can be as detrimental to a product's adoption as a technical limitation. As an example, customers in the Sound and Vibration space measure synchronization performance in degrees at a particular sample rate—e.g. to within ½ degree at 92kHz. In contrast, most other markets use a simple time offset—e.g. to within 15 nanoseconds.

CONVERGENCE TO MAINTAIN ALIGNMENT, SYNERGY, CROSS-POLLINATION

Most, if not all product designs require multiple domain experts to work together. This is the simple, forced coordination that naturally occurs as part of standard product development. But convergence must be wider than these interactions. Without careful consideration and design, this convergence may not occur where necessary. If too much interlocking can create indistinct products, additionally "too little connection among businesses results in isolated fiefdoms, duplication of efforts, uncoordinated products and

services, diminished ability to learn from one another, and disconnected strategies" (Brown & Eisenhardt, 1998, p. 60). Convergence allows for efficiencies across multiple product developments through re-use, the building of an aligned corporate culture and is key for sharing information to build competence.

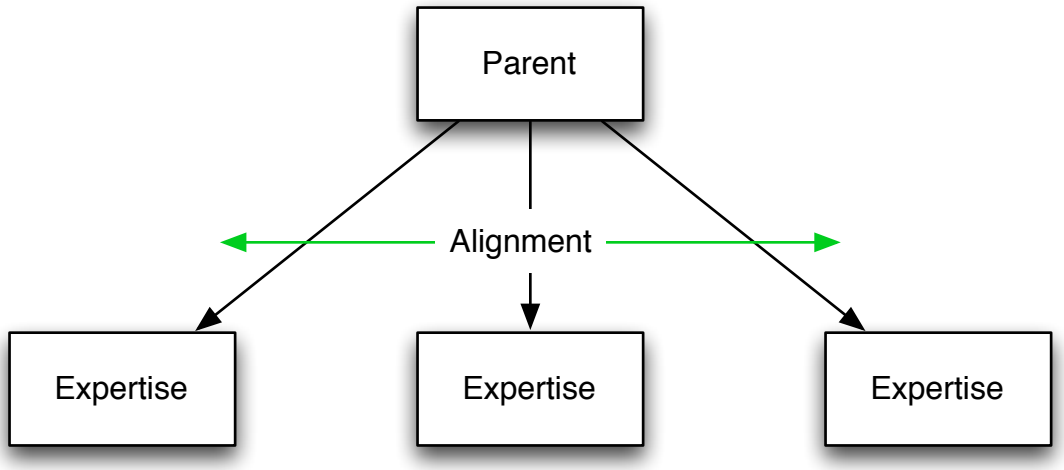

Figure 6: Simplified Organizational Structure

BOTTOM-UP DISCOVERY

NI culture has as a tenet the understanding that anyone in the organization can have that spark of insight that might pave the way for the next big thing. This is proven as "top-down knowledge inflows from persons at higher hierarchical levels than the manager are positively related to exploitation. Conversely, horizontal and bottom-up knowledge inflows from peers and persons at lower hierarchical levels are positively related to exploration" (Raisch & Birkinshaw, 2008). This is reflected in the current NI organizational structure that is relatively flat and has multiple forums for ideas from all ranks to bubble up and potentially gain traction.

Unfortunately, other business processes are built around the sustaining organizational mindset without considering the emergent. One such example is the

standard practice of looking at top 10 customers as part of a yearly roadmap. These top customers often make up the short list of visits for management teams looking to satisfy "their best customers." In many cases, the lower volume outliers are better indicators of new areas of growth but are ignored due to their relative size and/or fringe nature from the current core business.

STRUCTURED BUT ADAPTIVE

The organizational structure is a means to optimize the conversion of inputs into value for the customer. Over time, this formula will not hold as either demand shocks (shifts in tastes) or supply shocks (shifts in technology) challenge the equilibrium the organization has sought to optimize. In essence, the organization must be capable of recognizing these shocks and reorganizing as appropriate.

The natural evolution of a business results in processes designed to decrease variance and maximize return along the known path. The organization seeks to optimize existing business and builds an affinity for decisions that have been successful in the past. Over time, this causes perspective to narrow. These processes and procedures influence both day-to-day decisions along with more formal resource allocation activities. In sum, this builds an inertia that makes disruption more difficult to recognize and adapt to.

Thus, the resulting structure should be designed to shift to where the market is going instead of continuing too long with inertia preserving the now-stale direction. The concept of "Guided Evolution" presents an option for harnessing employees and other factors as a source of "variation" throughout a system. By building capability to sample and selecting from these variations, an evolution-like system is developed. This allows the organization to optimize along a primary vector while recognizing that natural

variation could be a source of insight as to how the system might need to adjust. (Lovas & Ghoshal, 2000)

Structure to Support Innovation Expertise

In a traditional product organizational structure, each division must grapple with the evolution of their customer base. A shock that might allow an initial product to be viable gives rise to the product area. This area seeks to overcome barriers like Moore's Chasm to mainstream adoption. Over time, the same group builds to a size suitable for keeping up with the mainstream market's needs. And as the market for the product begins to shrink, so does the size of the group since fewer new developments are needed and instead, the optimization becomes efficiency and maintaining the successful status quo. The product group supports the market throughout its entire lifecycle with an expertise in the product, despite the shifting needs and demands of the market as it develops.

Harvard Business Review's "Create Three Distinct Career Paths for Innovators" breaks innovation into three unique phases and instead, argues that each deserves building specific expertise. They dissect "innovation" into the separate tasks of "Discovery," "Incubation," and "Acceleration." Discovery is the creation or identification of a possible opportunity. Incubation is the experiment of that technology and business concept against both the potentially uncertain technology and market to design a model for a new business. Acceleration is the development of the business that can stand on its own. The authors argue the criticality of this approach versus the product-based alignment since "individuals with that breadth of skill sets are extremely rare" (O'Connor, Corbett, & Pierantozzi, 2009). For this reason, the organizational model should accommodate building both expertise in sustaining (exploiting) products and exploring new areas.

Organizational Components

The following organizational structure is a simplification to focus on the subject of product design challenges at hand. It does not include additional support functions outside of the scope of this thesis. It is of note that the sales force is a direct model that uses regional representatives with Engineering degrees.

PRIMARY STRUCTURE: FUNCTIONAL AREAS OF EXPERTISE

Product Organization: Broad Business with Areas of Expertise

The product organization supports the broad, core business. It is a single organization comprised of both Engineering and Marketing. It has a core expertise in accelerating products and sustaining a product line. Figure 7 provides an illustration of the following components.

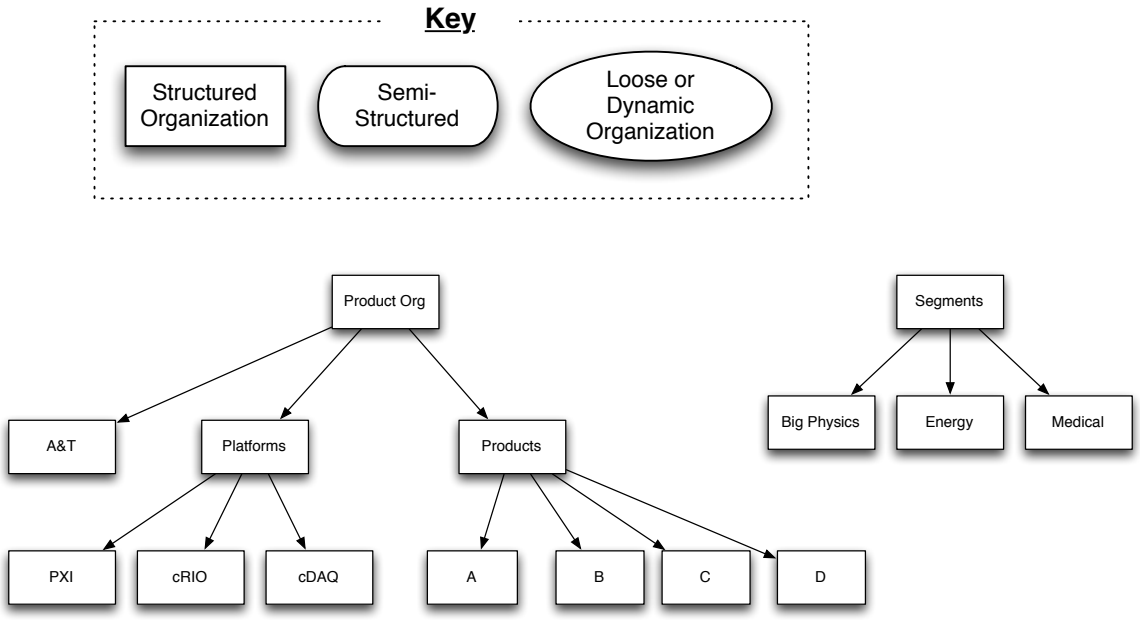

Figure 7: Recommended Primary Organizational Structure

Architectures

The first area that requires focus is the common architecture group. This area specializes in building designs that can be leveraged either in large volume or across multiple areas of the company. One method of reducing the cost of goods sold (COGS) this group has built a proficiency in is the design of ASICs (Application-Specific Integrated Circuits.) ASIC design demands building expertise both in specialized tools and lower risk development methods since these architectural investments are very expensive and widely deployed.

Platforms

The second area of focus is the platform group. The platform is an especially key component for modular hardware since it defines both the capabilities and limitations of every product within it. For example, the NI cRIO platform is a low power, rugged system designed for industrial environments whereas PXI provides significantly higher power, processing power and bandwidth but across a narrower mechanical and temperature range. The platform limits not only the overall environmental constraints but also what module types can be built within it and how they might be used together for different applications.

PXI Platform

cRIO Platform

Figure 8: NI PXI and cRIO Platforms

The platform decision is a long-term investment that multiple groups align to. It involves gathering requirements from a number of groups and designing a solution that can operate across a wide variety of applications. More than simple aggregation, the platform group should be highly technical and capable of designing ahead of where a survey of others would place it. This allows for a sufficiently long, scalable lifetime. It must also strike a balance between a platform that is too broad a solution (and in so, not solving a set of applications closely enough) and a platform that is too narrow (resulting in a fragmented, high investment landscape of too many solutions.)

Beyond technical requirements, the group must also have expertise in determining strategic platform options such as the openness of the design. An open platform can lead to wider adoption in the marketplace while a closed solution can provide differentiation and more control and agility. Open and other multi-participant platforms bring with them additional complexity in managing specifications, corporate relationships, etc. At NI, the PXI platform is an open standard built on PICMG Compact PCI while the cRIO platform is a more closely managed platform which has limited external influence and participation. Each of these areas of expertise is unique to a platform group, which is why we have created a platform area of focus.

Endpoint Products: Problem Domain and Solution Domain

The third area demanding focus to build expertise is each individual product area. In many cases, product groups require expertise to not only preserve working knowledge of the product itself but also to build a competency in key design skills. The degree of divergence within this area should be managed based upon the level of distinct expertise needed per product. If two products have nearly identical design constraints despite a different final product, there may be no need to diverge and create distinct groups at all.

For example, if a group has a need to design two products (DMM and DSA) across two platforms (PXI and cRIO), there are four distinct product needs in total. If the relative difference in the core product (DMM and DSA) design constraints is greater than the difference in the platform (PXI and cRIO) design constraints, it is more sensible to build focus along the product design constraints. In this example, the DMM group would build both the cRIO and PXI variants, as would the DSA group. On the other hand, if the platform design constraints are greater than the product design constraints, it may be preferable to build focus towards each platform. In this case we would have a cRIO group and PXI group each of which would build the products needed.

When determining whether there should be product focus, there are two distinct areas that should be considered: the problem domain and the solution domain. The examples we have used so far are in the solution domain. It is straightforward to understand that organizing for focus allows a group to build the technical expertise necessary to build a particular product. But similarly, the group must build expertise in the problem domain to understand the "job to be done." This includes how to communicate product attributes effectively (perhaps across different markets) and understanding the customer's alternatives.

Although the problem and product are related, the particular product is only one of many possible solutions. The subtlety is important for two reasons. The first is that the organization needs to be able to respond to demand shocks and supply shocks; adapting to provide a solution for a customer's "job to be done." The problem domain must be well understood because it may change based upon influences to the market (demand shocks) or the method of solving the problem may change (supply shocks.) The organization should be able to adjust its response to the problem without needlessly

perpetuating the previous solution. An organization designed solely around a particular solution complicates this shift.

The second is the organization may need to invest at different levels in the problem domain versus the solution domain. As an example, one product development group at NI had produced all the modular products deemed necessary for the market. Because the Marketing organization is directly coupled to R&D product output, this Marketing person was shifted to a different product area. Unfortunately, requests for the original product area now have no representative in the organization. This makes it difficult to represent the market because the organization was designed around the solution domain alone.

As an example of the first challenge, an organization could build an expertise in building and marketing DMMs. This will likely require precisely designed, custom analog circuitry to achieve "good" performance of 7 ½ digits of resolution. A demand shift example might be the problem domain finding an alternative that provides different raw capability but measures the same required phenomenea. In this example, it might be measuring system vibration (a DSA application) to monitor machine health instead of a previous method that accomplishes the same goal by precisely measuring current usage variation (a DMM application). A supply shift example would be a component supplier releasing an A/D converter that achieves a similar level of performance but without requiring the special expertise originally required. In both cases, direct alignment to the expertise needed for the original product is a hindrance in adapting to both the demand shock (application change) and supply shock (technology change.)

Market Focus: Segments

Segments build expertise by specializing in market areas. These market areas might be chosen for any number of reasons including their perceived growth potential, application fit or to garner market adoption for a discontinuous product. If the marketing domain in the product organization represents the problem domain, this segments group provides additional focus. By understanding the problem domain and specializing in a defined market, the segment creates a closer relationship to these customers and has a more honed pulse on a particular market. Because of the strengths required, sales expertise is key to this organization in also understanding the purchasing processes and politics of a particular market and set of customers.

CONVERGENCE

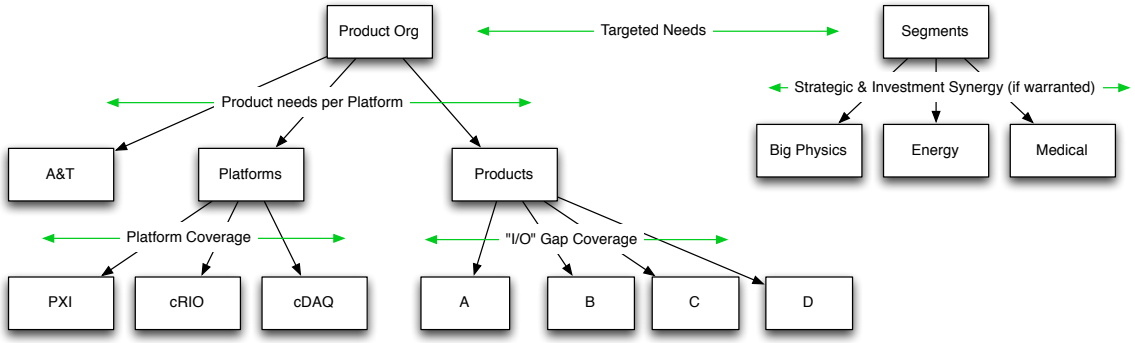

Figure 9: Recommended Primary Organizational Structure with Convergence

The primary structure allows building focus and expertise but it also serves another function; the coordinated alignment along the same structural lines. Consider the platform branch of the product organization. Each individual platform has characteristics that make it unique and require focus. But the set of platforms must be managed and controlled. The aggregation of responsibility to the platform group provides this alignment. The platform group can manage the set of platforms for the company by

knowledgably creating overlap or gaps. Without this convergence, the set of platforms would be difficult to manage, platforms would encroach or duplicate efforts and the overall platform offering would be non-optimal.

Similar alignment is needed for I/O coverage in the "Products" branch. This group works to determine what I/O is required and develops it based upon the area of expertise needed. The convergence allows explicit segmentation of product needs similar to the platform group. In the Product Organization itself, alignment provides complete visibility into and control of the product needs per platform.

Within the Segments group, convergence is required for strategic alignment. This ensures that a particular market strategy will be reasonably compatible with the other market goals and corporate capabilities. It might avoid, for example, Segment A seeking to be the low-cost solution and Segment B seeking to be the high performance vendor to their respective markets. These divergent strategies would require very different expertise and products to be successful. Due to a base of relatively common platforms and core competencies, such significantly different directions should be avoided and instead aligned unless divergence is absolutely necessary.

With a focus on gaining significant traction in a defined market with set boundaries, it is unlikely each Segment will be successful with the core product portfolio and no product adjustments or additions. Instead, the Segments organization can directly interface to the Product Organization to request segment-specific products that may not otherwise be undertaken as part of the general, broad business.

SECONDARY STRUCTURE: TECHNOLOGY FOCUS

This primary structure does not however provide all the support needed. A common need for an organization like NI is for technology to be identified and

communicated across the organization. A second need is for experts of a particular domain to have a communication path across a growing organization. Some key areas of expertise that are needed across the organization are Analog, Digital, Mechanical, Bus Technologies, Driver Software, Application Software, etc. The Product Organization structure's alignment takes a few of these domain experts and brings them together as a product group since most products require multiple domain experts.

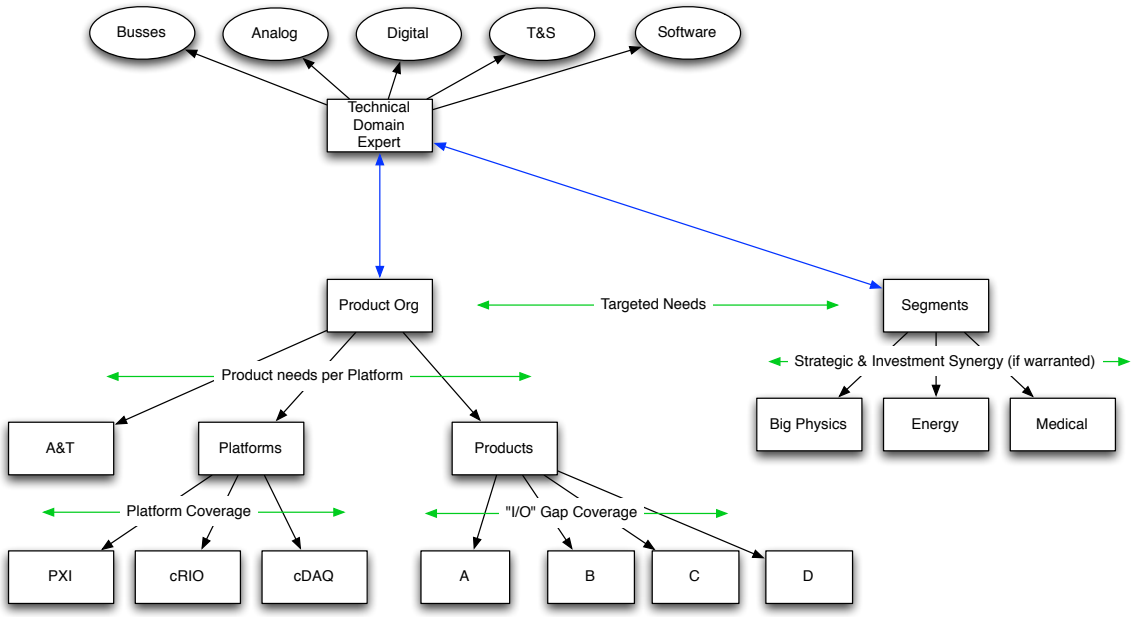

Figure 10: Secondary Structure Added to Support Technology Focus

The secondary structure seeks to support and facilitate this fundamental domain expertise. There is a formal ownership for fostering the network itself. This helps ensure accountability for preserving the structure. Since it is not the primary organizational alignment, it would otherwise fall apart. This group identifies domain experts, disseminates knowledge, and manages technologies. Technology management includes managing what technologies are tracked and assigning ownership for tracking and updating on key technologies as well as monitoring for new technology both close to our

domain (for direct application) or more distant technology (for broader technical consideration).

The secondary structure also serves as a network for other areas to find experts to support them where they may not have expertise. For example, the Segments are likely to have a primary expertise in sales. This structure would make is possible for Segments to identify internal domain experts that could provide a more senior perspective in an area they might otherwise be forced to interpret from a layman position. This work with the Segments would also benefit the technology domain by providing the domain experts visibility into other market technologies.

"SHIFT" GROUP

The "Shift" group is a key component of the organization designed to foster the paradox of exploiting existing opportunities and exploring to identify new areas of growth. "…Conventional wisdom goes wrong…in its assumption that entrepreneurship and innovation are natural, creative or spontaneous." And since "people work within a structure", we must build such a structure to support the entrepreneurial and new. As Drucker explains, the impediment to entrepreneurship isn't the size of the existing operation but is the existing successful operation itself. The exploitation requires "constant effort and unremitting attention" which is at the expense of the entrepreneurial organization (Drucker, 2001, pp. 137-138). And most organizations "fail to provide the formal structure and support that programs need to succeed, such as an autonomous organization, processes tailored for highly uncertain work, and well-designed metrics" (O'Connor, Corbett, & Pierantozzi, 2009). While not mutually exclusive, the natural tendency is for Exploiting and Exploring to not naturally coexist so an organization must be formed to do so.

In addition to identifying opportunities that might be separate from the core organization, the Shift group provides a complementary perspective on the core business itself. These might be new opportunities for existing products or new product changes that may complement or cannibalize the primary organization. The Shift group builds a organizational component capable of considering and anticipating disruptive shifts that the exploiting part of the business may be too focused to notice.

Royal Dutch/Shell implemented a similar "GameChanger" process that went live in November 1996 to support and fund new ideas from the organization; unfortunately very few "revolutionary thoughts" materialized. Shell realized that they needed more than just venture funding to build innovation. Instead of simply providing funding, the GameChanger team designed a three-day "Innovation Lab" where they were taught how to "identify and challenge industry conventions." At the conclusion, an "Action Lab" provided the forum to turn the ideas into credible venture plans including developing "low-cost, low-risk ways of testing the ideas." What Shell realized is that funding wasn't enough; they needed a catalyst to foster and nurture innovation not only through initial discovery but also the shaping and reforming of the concept as it grows. (Hamel, 1999)

Non-Centralized, Support Structure

The Shift group itself has some similarities to the Distributed Innovation Group described in Harvard Business Review's "Teaming Up to Crack Innovation & Enterprise Integration." The Shift group supports the "Innovation" described as "doing new things that customers ultimately appreciate and value [not simply new technologies]" (Cash, Earl, & Morison, 2008). The Shift group is not focused on technology alone. It must explore both market and technology shocks. Drucker suggests that innovation "be focused" where "the core does not have to be technology or knowledge. …Market

knowledge supplies a better core…than technology does" (Drucker, 2001, p. 276). The experts who comprise the Shift group must create, in combination, an expertise in innovation for both Marketing and Technical vectors. They must be able to take the unexpected successes and failures and through market focus, identify whether opportunity exists that should be pursued (Drucker, 2001). Figure 11 illustrates the Market and Technology distance that the Shift group might explore while the core business is engaged in exploitation activities. The vertical axis indicates closeness to the core market served and the horizontal axis indicates the technological distance from current solutions.

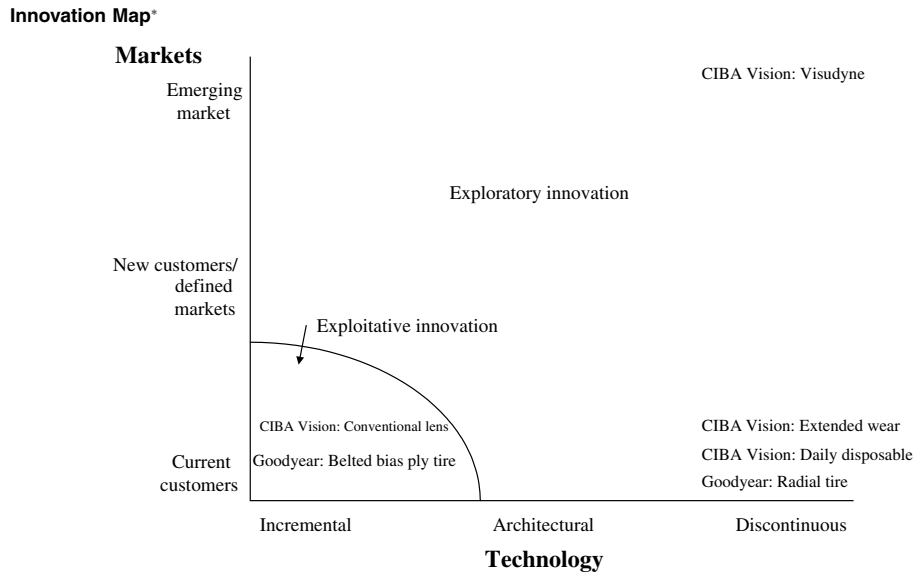

Figure 11: Innovation Map Highlighting Market and Technology Trajectories (Smith & Tushman, 2005)

The Shift group acts as an "active, technology-enabled [agency] to promote innovation and integration—to overcome obstacles, focus effort, and let the unnatural acts become more natural." It "recognizes and promotes innovation" to "convert corporate scale into an asset rather than a hindrance to innovation initiatives" (Cash, Earl, & Morison, 2008). Table 3 illustrates the fundamentals of the Shift group, which were adapted from the Distributed Innovation Group concept.

Is	**Is Not**
A scout for potential ideas within the organization—"…uncovering untapped potential of latent ideas as well as discovering new ones	A group solely responsible for product and technological discovery—Discovery is a distributed process
A monitor of the external environment for emerging technologies and their market applications	An isolated group entirely separate from the core organization
A Facilitator for ideation	A Diversification method
A center for innovation expertise including Discovery, Incubation and Acceleration.	

Table 3: Shift Group Overview; Adapted from Distributed Innovation Group (Cash, Earl, & Morison, 2008)

Symbiotic with Breadth Business

The Shift group is not a rogue entity entirely separate from the core business. To extend the handedness metaphor, the left hand is different from the right but both are still connected to the same body and know what each other is doing. The Shift group is complementary to the variance-decreasing organization by focusing on variance-increasing activities. This gives the organization as a whole a better perspective. On the subject of creativity, it is suggested: "you want people to work at the ends of the Gaussian distribution. Efficient models make good sense for the middle and end stages of

the innovation process, when the game has moved from discovery to control and reliability" (Amabile & Khaire, 2008).

But this is not a one-way street. The Shift group is not a completely isolated part of the organization since it must stay closely related to the core. "Innovative efforts that take the existing business out of its own field are rarely successful." "The new is always sufficiently difficult not to attempt it in an area one does not understand. An existing business innovates where it has expertise…" (Drucker, 2001, p. 142). In this way, the sustaining organization and the Shift group provide each other shared capabilities beyond their individual area of focus (Raisch & Birkinshaw, 2008).

Early Market Sampling of Fringe Use Cases

The broad nature of the sustaining organization provides a key resource to the Shift group and is related to early market adoption of broadly applicable products. Variable market isolation—described earlier in this paper—assists in the early market adopting a technology before they have enough references from the market in which their mainstream counterparts might later live. This set of early adopters provides a sample set of customers to consider when assessing possible innovation opportunities.

A second reason this set is such a key resource is because of the breadth and modularity of the products involved. Traditional product design creates pointed solutions where there is a market large enough to provide some confidence in a reasonable return. NI products provide integration across the portfolio of products. This allows for significantly greater integration between a wide variety of components than possible with traditional solutions. This increases the likelihood of satisfying use cases that span boundaries between traditional, pointed solutions.

Early adopters would otherwise satisfy these problems with custom implementations. But particularly with the price insensitive early market, the integration between modular offerings makes them a viable alternative that can provide another sample of the early market. Figure 12 illustrates the focus of traditional, fixed solutions on markets with a large perceived opportunity while modular solutions with horizontal integration can instead solve applications that would otherwise be underserved. The x axis indicates the set of possible functionality and the y axis illustrates the perceived market size of the area.

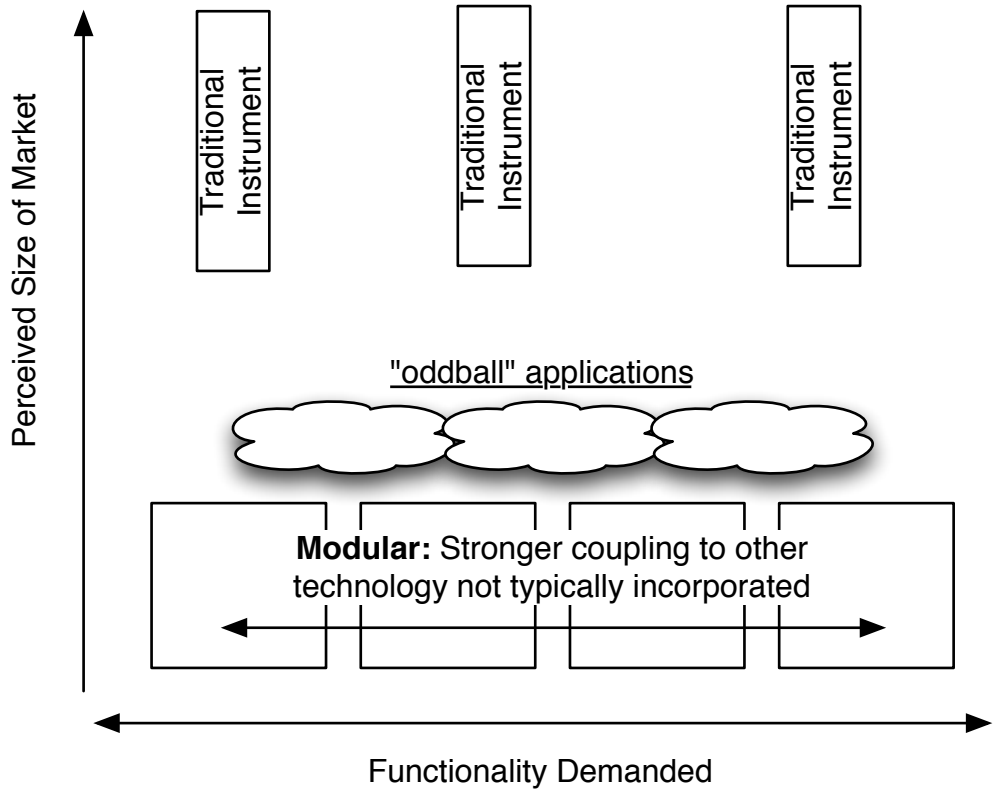

Figure 12: Modular vs. Traditional Application Coverage

Stability: A Prerequisite for Risk

One benefit of a diverse product portfolio described earlier is a stable base. This stable foundation was found by a U.S. Department of Labor investigation to be a key

factor for successful innovation. Job security allows employees to experiment without being concerned with a negative outcome directly affecting their well-being. At a larger level, the organization supports exploratory efforts with a stable cash flow, which similarly allows experimentation without directly incurring negative repercussions from a failed attempt. This low risk support system helps ensure the Shift organization can maintain a "risk taking" attitude with experimentation and aggressiveness (Leonard & Swap, When Sparks Fly, 2005).

Shift: Separate Hands

"This means, first, that the entrepreneurial, the new, has to be organized separately from the old and existing." And "there has to be a special locus for the new venture…and it has to be pretty high up." (Drucker, 2001, pp. 138-139). "Often, the best way to achieve true dexterity is to set up separate, autonomous organizations. This has the effect of keeping the two hands at, well, arm's length" (Moore, Strategy and Your Stronger Hand, 2005).

Three successful examples Drucker identifies as practitioners of this approach are Proctor & Gamble, Johnson & Johnson and 3M. "They set up new ventures as a separate business from the beginning and put a project manager in charge…until the project is either abandoned or has…become a full-fledged business. The project manager can mobilize all the skills as they are needed—research, manufacturing, finance, marketing—and put them to work on the project team" (Drucker, 2001). Christensen and Raynor's "The Innovator's Solution" describes key rationale for separating the disruptive from the existing business. This is illustrated in Figure 13. Note however that due to the nature of NI's products—they're used in combination and not separately—our argument is that the Shift portion of the business should be separated.

Figure 13: Christensen and Raynor's Recommended Organizational Structure (Christensen & Raynor, 2003, p. 192)

The measures and processes must be aligned with growing the new business as well. Drucker makes a comparison between infants in the nursery and "adults." Infants don't have the time or understanding to satisfy the requirements asked of adults. The motivators built to sustain and optimize the existing business can stifle or derail the new enterprise. Drucker identifies a case from a "major chemical company" that completed scientific work, which then stagnated. Finally it became clear that new ventures were stalling as the primary compensation structure made new ventures highly undesirable, even avoidable. Eighteen months after a change to this incentive structure the new materials were on the market. In another case, Seagate has succeeded in shifting into new

markets by following the path to "stop listening to its best customers so that it could instead pay attention to raw new markets" (Anders, 2007).

In all, Drucker's "most important caveat is not to mix managerial units and entrepreneurial ones." As it is "almost a guarantee of failure—for a business to try and become entrepreneurial without changing its basic policies and practices. To be an entrepreneur on the side rarely works." (Drucker, 2001, pp. 141-142)

Separation of the Shift group from the core business allows the organization to simultaneously pursue both incremental and discontinuous innovation and change but provides each area enough isolation to focus on building expertise for their very different goals. The separation of the Shift group also makes possible the extension of the ambidexterity concept to "polydexterity which will require firms to coordinate businesses that are both complementary and competitive in the current marketplace at the same time" (Bodwell & Chermack, 2010, p. 198).

But Without Walls

Organizational delineation of the Shift group from the existing business is a requirement but it must also be capable of interfacing throughout the company and bridge expertise from different domains. "Creativity that will result in useful innovation thrives in a partially controlled ecology…" with "ample freedom for ideas to roam" but also "boundaries and fences" (Leonard & Swap, When Sparks Fly, 2005). The Shift group must have the ability "to ferret out unmet needs" thus working "with fellow explorers from other areas of expertise" (Bodwell & Chermack, 2010, p. 196).

Creative Abrasion

One key reason for building the Shift organization with focus but without complete isolation is that diversity breeds more creativity than homogeneous groups.

"When Sparks Fly" argues that "Aliens" are critical to building what they term creative abrasion. They "ask 'dumb' (i.e. unexpected) questions" with a "beginner's mind" which cause those deeply familiar with the subject to reassess their preconceptions, leading to opportunity for creative insights. A completely homogeneous group is without dissimilar views. This should be avoided since dissimilar views are critical to stretch each individual's perspective, which is key to creativity and innovation (Leonard & Swap, When Sparks Fly, 2005).

Aliens should provide a deep knowledge base in a particular area different from the perspectives already available. For the Shift group, this perspective might be required from various areas of the organization. Bridging experts is desirable versus the alternative of working with broad individuals because of the opportunity at the intersection of different deep expertise. Those with deep expertise but also capable of bridging to other domains are said to have "T-shaped skills" because they can facilitate the intersection (the horizontal part of the "T") of depth (the vertical portion of the "T") to other domains.

BRIDGING EXPERTS: CONVERSATIONS FROM AMBIGUOUS TO THE CONCRETE

As the organization grows, experts of a particular domain must have capability to share experience and expertise with others of similar focus. Additionally, convergence of experts is central to innovation and creativity (Leonard & Swap, When Sparks Fly, 2005). The usual intersection of experts is at a level where each brings to the table what they know. Unfortunately, this is ineffective for optimizing the potential breakthroughs when connections are made between areas of expertise.

An example is when a development group attempts to present to and gain insights on their product plans from domain experts. With the wide applicability of T&S across multiple platforms and markets, this is a common challenge. The traditional dialog

includes a presentation of the product concepts and plans from one group to the other domain experts. Feedback is provided and adjustments are made as necessary. The duration of this interaction is rarely more than an hour.

Unfortunately, this brings significant limitations in gaining feedback useful to innovation. Resolution of the time constraint and one-to-many format is reasonably straightforward. But the most significant problem is the limited scope each participant is considering as part of the discussion. Figure 14 illustrates the dilemma. An expert's knowledge consists of elements with varying levels of confidence. There may be some they are absolutely certain of and others that are little more than unlikely possibilities. Bridging experts from different domains requires a forum that allows intersection of these separate domains. This often requires bringing more to bear than those certainties close to the core of their domain expertise.

Finding intersections requires expanding to include the set of knowledge each expert might have less confidence in by building a conversation and environment conducive to this task. One method is starting with a very broad conversation to try and pull each expert toward each other. By then increasing the level of certainty, the group can determine how far the intersection might extend. All intersections, from the improbable to the certain should be considered as possible innovation paths to move forward.

T&S Experiment

The NI Timing and Synchronization (T&S) group performed an exercise on this concept by bridging the NI Timing and Synchronization group with domain experts who were focused-on and thus well versed in, domain applications of NI technology—analogous to the aforementioned Segments. The exercise allowed an exploration of

possibilities with access to deep knowledge in the Timing and Synchronization space and deep market expertise. The results were significant.

Most intersections like these are formalized presentations of roadmap plans where vetted concepts with an associated timeline are presented to other groups for awareness. Unfortunately, these intersections are both too formal and too conservative to generate the creative abrasion necessary to make innovative shifts. Instead, it requires a special forum with groups who might generate something interesting where they converge.

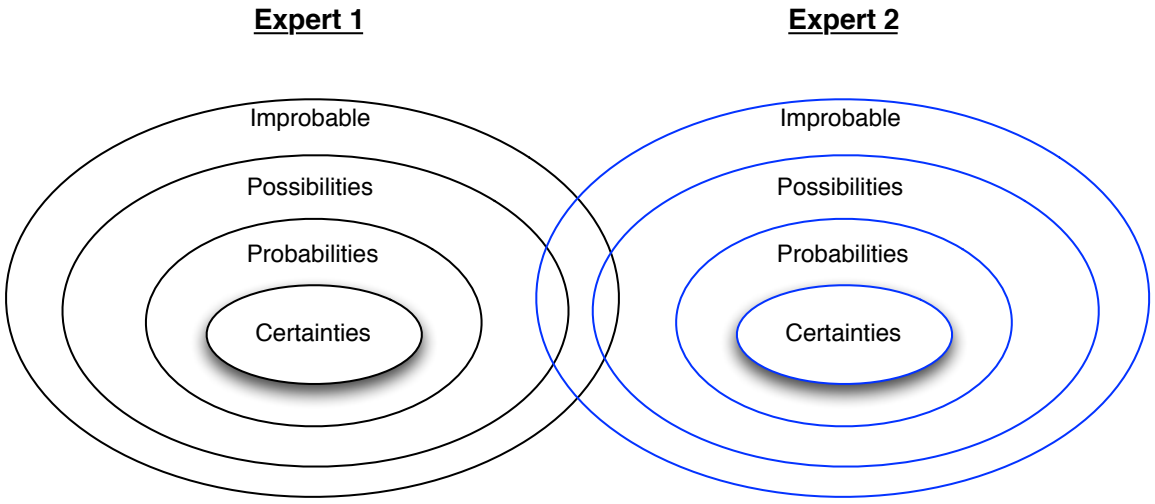

Figure 14: Intersection of Expertise

By bridging the technology experts with the market experts, new insights can be gained. What was most interesting about these discussions was that the insights gained would not have been gleaned through any single-direction flow of information, which is the usual communication mechanism within the organization. Instead, an iterative, continually adjusting conversation is needed to identify small avenues of the conversation and focus on exploring them to learn more.

An example of this led to an insight of applying a new synchronization technology to a market that at first glance would have no need for it. The technology allows for synchronization at no-cost, across the platforms designed to address the market. In the words of the market expert, this market "doesn't care about synchronization." But during a dedicated session, the team was able to explore with each other eventually determining that the new, no-cost technology could be used as a strategic differentiator versus the competition. Using the standard, unidirectional communication paths, the market experts would never have requested new synchronization technology because they expect it will have an associated cost and the Timing and Synchronization technology team would have never designed a product for a market that "doesn't care about synchronization."

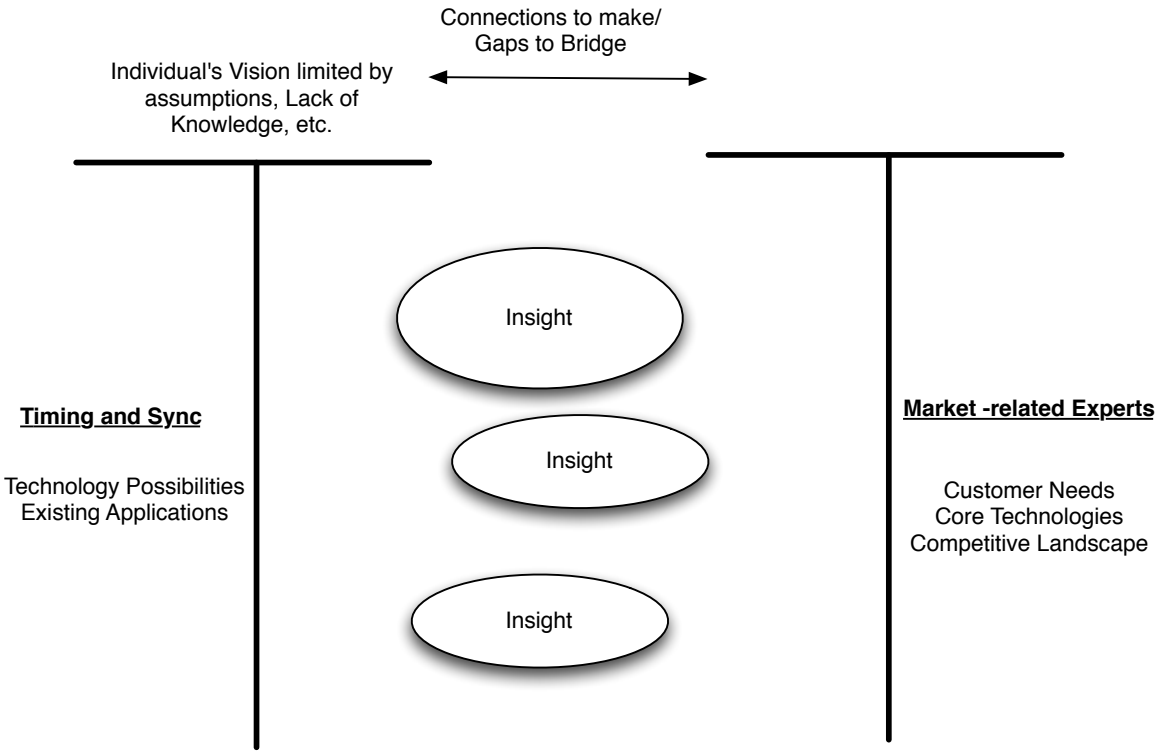

Figure 15: T-Shaped Bridging to generate Creative Insights

Build Bridging Expertise

While Aliens provide the opportunity to benefit from their perspective, they must be carefully integrated for interactions with the core team. An example is that aliens should be provided their own "Allies" which support the alien viewpoint so it isn't snuffed out by the psychological pressure from the other members of the group. The Shift group must be familiar with the psychological tendencies in these interactions and build an expertise in managing and fostering these intersections.

Avoiding Groupthink by Injecting New Blood

Bringing Aliens into the fold to generate new, larger, creative outlooks is a key method to avoid groupthink where the least common denominator is the only outcome

that survives. This is where the disruptive challenges creativity demands are not fostered but subsumed by the group itself. In fact, over time a group that begins as disruptive can become so familiar to each other and so persuaded to maintain relationships that they homogenize themselves and become less innovative and creative (Leonard & Swap, When Sparks Fly, 2005). But from the broad organization, the Shift group has a pool of potential expert Aliens from which to get an injection of disruptive insight. Considering this, the size of the Shift group should be dynamic, based on the task at hand, and comprised of experts from across the organization arranged to provide not only deep expertise but also dissenting—and thus complementary—perspectives.

Falling Forward

Exploration brings with it uncertainty which will certainly encounter failures. The goal of the Shift group should be to make sure these are intelligent failures—failures that were purposeful and taught a lesson in the experience. "Falling forward" allows some level of learning that can then be applied elsewhere. This is starkly contrasted with useless failures from which the organization does not learn. The Shift group should not only be capable of identifying failures and learning lessons to apply in the future but also in building the experiments and teams around them so any failures encountered can be leveraged moving forward. The group should leverage their awareness for emergent opportunity to evaluate each failure for potential in areas outside the original target. With a single structure and access to the breadth of markets and products these emergent insights have greater opportunity to be directly applicable to another area of the business.

Key Innovation Phases

Harvard Business Review's article "Create Three Distinct Career Paths for Innovators" positions incubation into three primary phases: Discovery, Incubation and

Acceleration since the phases require distinct expertise and "individuals with [the] breadth of skill sets [for every phase] are extremely rare" (O'Connor, Corbett, & Pierantozzi, 2009). These three phases with the additional Handoff phase to the exploitation part of the organization become key phases for the Shift group to facilitate.

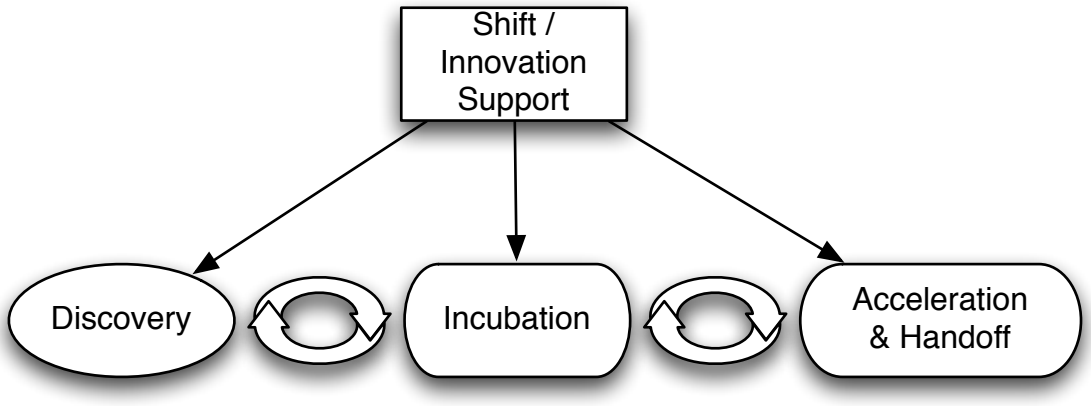

Figure 16: Shift Group Key Phases

Discovery

Discovery is the art of "opportunity generation" and using "bench science" to assess feasibility. It includes not only technical opportunities but also exploration in the market for opportunities as well. While the core organization may use defined processes, resource allocation and analysis to identify opportunities, the Shift group specifically seeks to identify areas where an "asymmetry of motivation" would make it difficult or impossible for the core organization to respond (Christensen & Raynor, 2003).

Discovery is art. It requires adapting to see a situation from different perspectives to add value to the core organization. Both identification and processing of the information needed during discovery is challenged. "End-user intelligence that comes back can be a lot hazier and harder to sort out than a nice two-hour PowerPoint presentation by an existing big account" so it is more difficult to both identify sources of

potentially-valuable information and process the information once it is gathered (Anders, 2007).

Traditional organizations like Bell Labs created dedicated research wings to support exploratory work. Unfortunately, this makes it difficult to foster the intersections of experts that are so valuable for innovation. It also limits the set of individuals who generate sparks of insight to a select few who would likely tend to homogenize over time, thus reducing their creativity. Instead significant research is pointing towards bottom-up discovery as preferable to the dedicated wing approach. "Top-down knowledge inflows from persons at higher hierarchical levels than the manager are positively related to exploitation. Conversely, horizontal and bottom-up knowledge inflows from peers and persons at lower hierarchical levels are positively related to exploration" (Raisch & Birkinshaw, 2008).

The argument against top-down or isolated innovators is significant. "First, where in the pyramid will you find the least genetic diversity in terms of how people think about the business? Second, where in the organization will you find people who have most of their emotional equity invested in the past? And third, where will you find people who have, for the most part, already 'made it'?" (Hamel, 1999). Similarly, from an "analysis of innovations at Google: its founders tracked the progress of ideas that they had backed versus ideas that had been executed in the ranks without support from above, and discovered a higher success rate in the latter category" (Amabile & Khaire, 2008).

Instead the goal should be to facilitate idea generation from those throughout the organization. This includes encouraging cross-pollination across non-standard lines to generate creative abrasion. The Shift group can connect experts who wouldn't normally intersect in the standard business but whose intersection provides unique opportunities for insight. As a concept, guided evolution is similar. It seeks to leverage variation—

including variation of ideas—from across the organization. This is an example of applying selection and focus while embracing broad sources of variation and innovation. The Discovery phase supports this concept.

Thus the Shift group has a responsibility to the Discovery phase of Innovation but it does not pursue it in isolation. Instead, it seeks to catalyze the rest of the organization supporting a bottom-up innovation structure and to "tap ideas from all ranks" (Amabile & Khaire, 2008). Instead of attempting to be the sole source of ideas, the Shift group supports and facilitates idea generation from any area within the company through its focused expertise in discovery itself.

Incubation

Incubation is the experimentation and iteration with technology and business concepts in an attempt to design a viable model for a new business. It is deeply rooted in exploration and emergent strategy with an understanding that adjustments must be made based upon technological or market feedback. "Most successful entrepreneurs understand that they need to 'pivot' as they get additional data and learning." This is what Cagan terms "Product Discovery;" iterating to determine what the product should be (Cagan, 2009). This "pivot" is a shift from the direction originally intended to better serve given the new knowledge the iterating provided. Incubation supports this understanding that entrepreneurial and exploratory areas need to be open to discovering what product they have opportunity to exploit.

During this stage, optimizing iterative learning is key. The existing, standard learning cycle for a product is illustrated in Figure 17. It consists of the R&D organization that designs and develops products. These are then transferred through the Marketing and Sales channel to the customer. The internal vetting that takes place as part

of a project kickoff is not illustrated. It is assumed that for a disruptive technology, this internal-only vantage point provides limited learning opportunity versus the customers themselves.

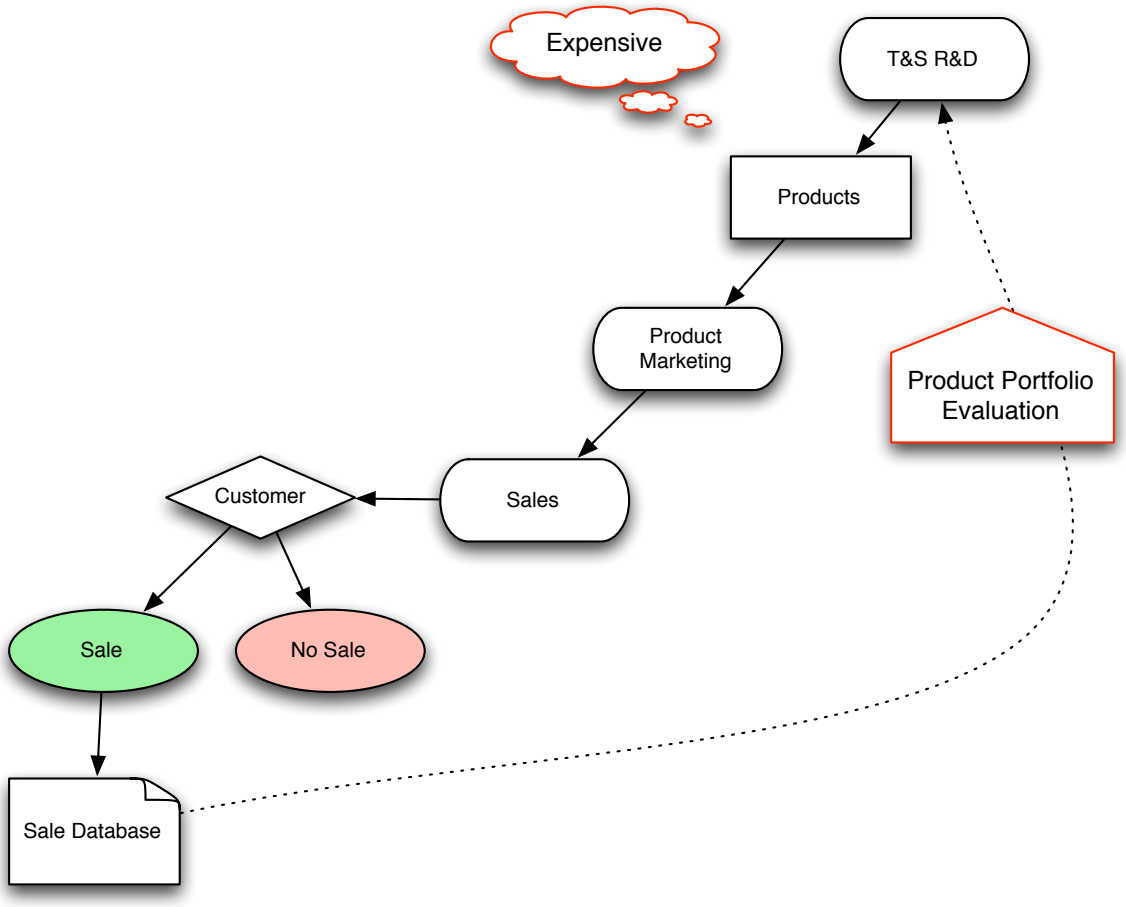

Figure 17: Standard Iterative Learning Cycle

Unfortunately, not only is this process expensive in both time and resource cost, but the path for iterating is highly imperfect. The channel is lossy with thousands of products to communicate; the engagement to the right end customers is prioritized not on usefulness of feedback but possible sales revenue; and in the event of no sale, there is no mechanism for identifying product deficiencies unless the loss was of an opportunity so

significant that it demanded direct engagement. The Shift group's incubation stage seeks to create expertise in building low-cost, rapid, and valuable iterative feedback to adjust the innovation and move forward. It must decrease the iteration time to build agility into the process.

This requires an expertise in selecting the right customers to provide feedback. Often these customers are not at the core of the market that the organization intends to address. Instead, extreme examples at the edge of the distribution often exhibit the same characteristics as those in the valuable core but in more identifiable proportions which are thus more valuable for iterative learning (Patton, 2010).

This includes a need to correct any channel bias that might undermine connecting to the right customers. If the existing channel is used, it must be monitored for bias towards the incentive structure in place. For steady-state business, this optimization towards the most profitable customers is appropriate but for exploration, it may be the opposite of what is needed. The new channel may not be appropriate for these "right" customers either. New customers often purchase from a new channel. And disruptive products often require disruptive channels to be effective (Christensen & Raynor, 2003).

It also requires an expertise in the design of the product to be iterated against. The first distinction is one of Engineering; that the product for rapid iteration should not be the same product intended to satisfy a large customer base or become a technology platform for the next generation of products. The form most suited for this product is often a prototype. But while a standard development process may create a prototype which seeks to mitigate risk, appease differing views and be a step towards the eventual (likely conservative) product, a prototype in the incubation stage should be designed explicitly to test boundaries, stretch possibilities and instead see where the possible market is willing or unwilling to go.

The "agility approach is suitable for projects with high levels of uncertainty and risk and frequently changing environments. A stability approach is appropriate for projects in which 'the requirements are stable and predictable, and when the project is large, critical, and complex'" (Bodwell & Chermack, 2010). The explicit distinction between the goals of the agile versus the stable development processes helps keep the incubation stage prototyping separate and with a distinct focus. This allows better management of the uncertainty and risk through which incubation must learn by keeping it lightweight, focused and low risk/cost.

Acceleration

Acceleration is the stage focused on building the business to the point that it can stand on its own. This includes optimizing and building processes, imposing discipline and repeatability. It is the stage at which the organization shifts from exploration towards exploitation, honing processes to ensure the business can be supported and perpetuated. Moore's "Inside the Tornado" describes the rapid acceleration some products experience after the Chasm. Key competencies needed for this stage include managing and coping with this rapid adoption for an early business (Moore, Inside The Tornado, 1999).

Handoff: A Well-Oiled Machine

The Shift group's work is not simply building options for opportunities. It must work on building opportunities to the point that they can be managed by the Product area of the organization that is more adept at general product line management. "Research on dynamic managerial capabilities and organizational change has focused on how leaders can successfully innovate to enable adaptation…This focus on adaptation may lead to suboptimal performance. Instead, we argue that sustained performance occurs through attending to and dealing with strategic contradictions—short-term performance and long-

term adaptability, exploration and exploitation, focus and flexibility" (Smith & Tushman, 2005). The handoff phase is not necessarily a discrete step. It must be an endpoint that the Shift group consistently works towards alongside the primary Product organization as the product develops and matures. This way both parties are invested and prepared as the innovation matures towards Handoff.

Shift to Complement Existing Focus

The Shift group is not limited to entirely new domains. Even in areas where a formal structure—such as a Segment—supports a particular market, a Shift perspective is needed. This is simply because of the different motivations driving the Segment organization versus the Shift organization. Segments are primarily a sales focus with key performance metrics of market share and growth of sales. These are reasonable measures since the market is well defined and penetration is the primary objective. This resulting focus supports the greatest areas for profitability in a traditional ROI-maximization methodology.

Unfortunately, this focus may have significant drawbacks when it comes to identifying changes that might necessitate focus for larger market gains in the long term. This is where the Shift group can provide a complementary focus towards the leading end of the curve with a focus on changes in the market due to demand or supply shocks. Figure 18 illustrates Moore's adoption lifecycle and the two primary areas the Shift group creates value. The first (leftmost) is the identification and incubation of new areas of opportunity, adjusting with the emergent strategy that unfolds and might be handed off to become a part of the business long term. The second is the awareness of changes to the market while the primary organization focuses on maintaining the business for the profitable majority in the market.

Figure 19 illustrates the areas of the market the sales-focused organization chooses to optimize based upon larger immediate revenue potential. In contrast, a strategy of monitoring and leading the early market might lead to a larger long-term market share. Neither perspective is individually sustainable. But in balance, these two areas working together should mitigate the Innovator's Dilemma.

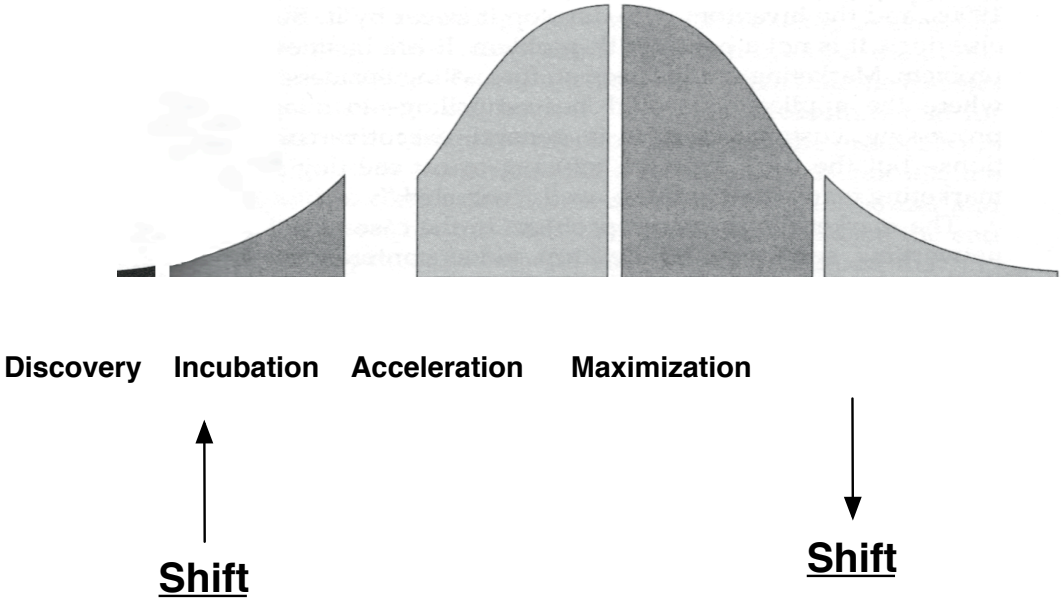

Figure 18: Illustration of the Shift Group's Primary Market Effects

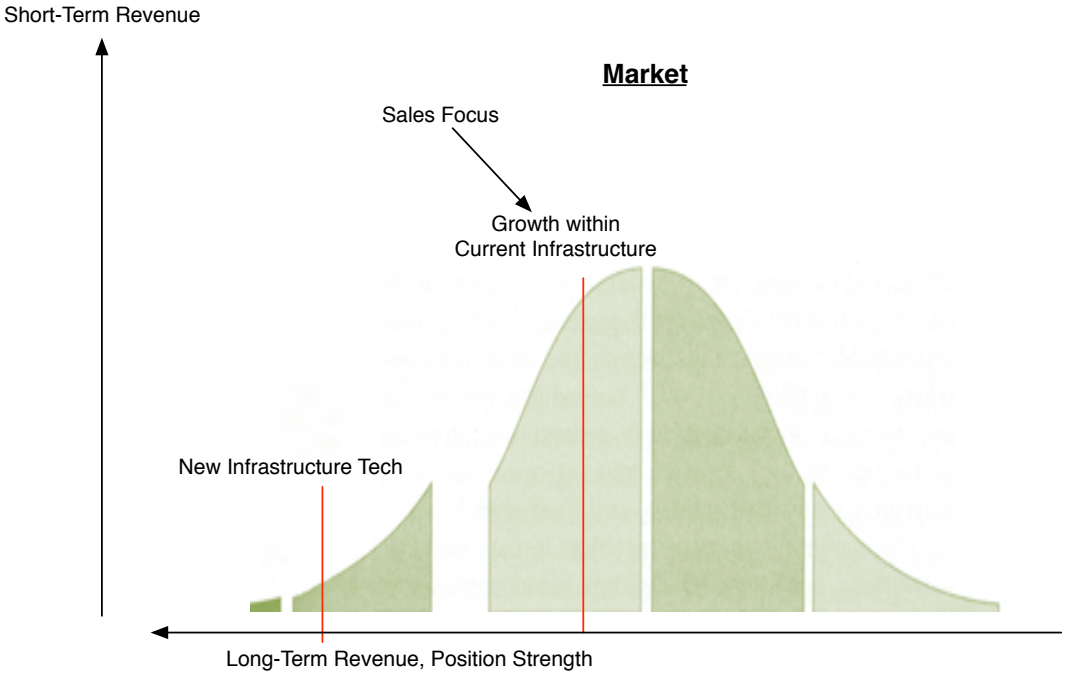

Figure 19: Focus on Different Areas of the Market

SUMMARY

Key Distinctions From the Current Structure

The complete recommended organizational structure is illustrated in Figure 20. For comparison, a simplified version of the current NI organizational structure is provided in Figure 21. Key distinctions are captured and discussed.

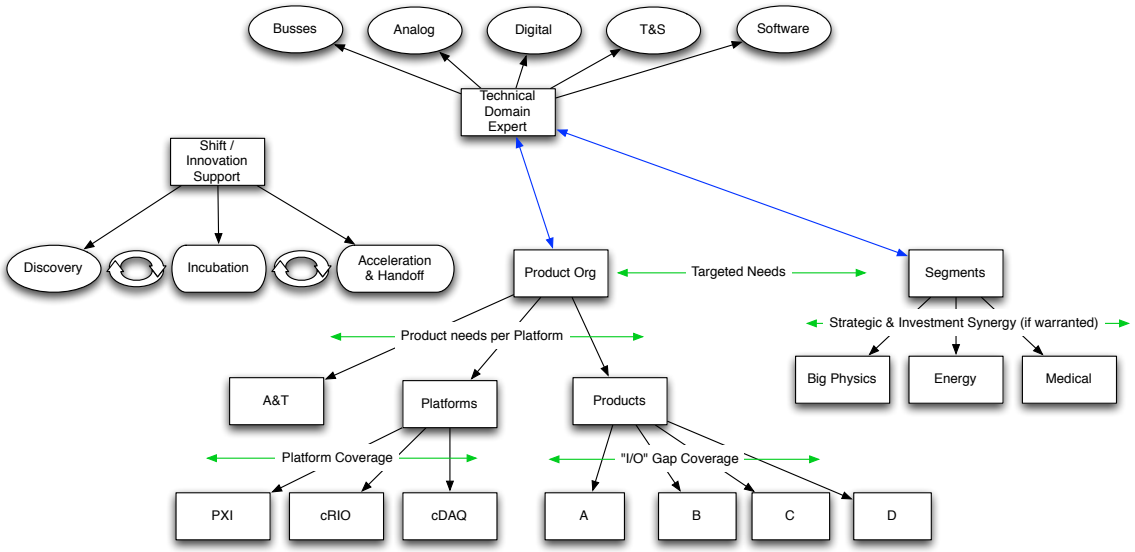

Figure 20: Recommended Organizational Structure

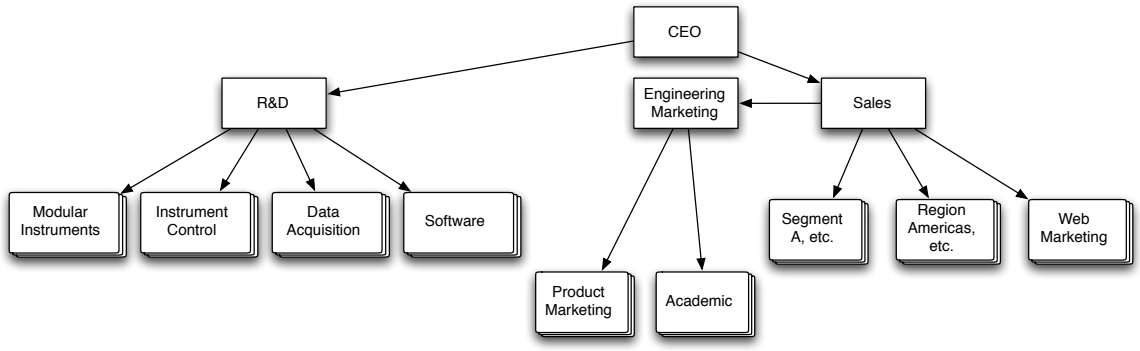

Figure 21: Simplified Current NI Organizational Structure

The first notable difference is that Engineering Marketing and R&D are not part of the same organization. This limits the scope of product decisions that can be made

since an increase in Engineering development investment does not necessarily bring with it an increase in Marketing investment and vice versa. Additionally, the focus of the Marketing area on the problem domain and the R&D on the solution domain is not maintained in the current model.

Secondly, platforms aren't aligned under a particular organization. While experts in platform development are coordinated when the consideration of a new platform or change to platform is forced, alignment is not naturally maintained by the structure and platform overlap or gaps are more possible.

Four Vice Presidents manage the R&D area. The delineation of products has the same challenges as previously described—customers use products from across these "product" boundaries to build their system. While a relatively flat structure, this separation of product functions limits visibility across areas.

The only Segment alignment is to the VP of Sales directly. This creates limited bandwidth for aligning the five segments that exist currently and may become more difficult as the number of segments grows.

There is no formal secondary network to support technical cross-pollination. The network of technical experts with similar focus exists but is not well defined and perhaps more importantly, is not bridged as a resource to other parts of the organization. This serves to limit how much cross-pollination can be accomplished and whether parts of the organization such as the Segments can leverage this expertise.

Discovery, Incubation, Acceleration is not supported by an explicit organizational structure. Forums such as "NI Tech" (a three day technology forum) and the culture of the organization deeply embed value for innovation but are likely far less effective and sustainable than if an organization like the Shift group were in place. Because of this lack of a separate organization to foster innovation, research would lead us to determine that

the primary structure and its focus on deliberate, variance-decreasing activities would serve to undermine work towards innovation. Additionally, innovation is difficult to accomplish since it likely requires mobilizing areas across the organization, which an individual wouldn't have access to or control over.

Lastly, since there is no group to monitor technology explicitly, this task is replicated across various parts of the organization. Similar to many of the other design challenges with the current structure, this causes inefficiency through rework and potential gaps where it is unclear if a technology is being or should be monitored.

Conclusions

There are distinct management difficulties for a modular organization serving (1) a broad set of customers (2) with a product that requires them to change behavior that (3) leverages high technology products. The natural evolution of a business seeks to optimize behaviors to reduce variability through processes. This exploitative focus builds inertia and with it an inability to react to discontinuous shifts. Breadth brings with it distinct advantages that we seek to maintain as a business but must coexist with focus on key challenges of discontinuous product adoption.

The suggested organizational structure seeks to mitigate these challenges by building ambidexterity into the organization. This "Genius of the And" approach seeks to manage the inherent paradoxes of: breadth and focus, sustaining and disruptive innovation, deliberate and emergent strategy, exploitation and exploration, and structure with adaptability. These seemingly contradictory perspectives challenge and support each other creating a whole that is more capable of adapting and aligning than its individual parts.

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